

DFO - Library / MPO - Bibliothèque



07014566

8152

RECEIVED

JUN - 3 1992

*bfad.*

**BIOLOGICAL SCIENCES BRANCH  
FISHERIES AND OCEANS  
SCOTIA-FUNDY REGION**

**PROGRAM REVIEW, EVALUATION  
AND PLANNING**

**REVIEW YEAR 1991  
PLANNING YEAR 1992**

GULF FISHERIES LIBRARY  
FISHERIES & OCEANS  
BIBLIOTHEQUE DES PECHES GOLFE  
PECHES ET OCEANS

**PROGRAM REVIEW, EVALUATION, AND PLANNING 1991-92**  
**SCOTIA-FUNDY REGION**  
**BIOLOGICAL SCIENCES BRANCH**

**INTRODUCTION**

The Program Review, Evaluation, and Planning (PREP) process is the cornerstone of the Biological Sciences Branch's annual planning cycle. This cycle consists of a number of interrelated exercises including review and planning for projects (this document), Work Planning (mainly financial planning), and appraisals (of individuals). A project is a well defined activity, which can be operational or scientific in nature, which may have a finite life span, or can be ongoing. A project form reviews a functional entity, often describing the work of a group of people, as opposed to appraisals which focus on individuals. Projects are linked to work planning and budgeting aspects through a common numbering system - i.e. the Financial Management System (FMS) Cost Codes and the PREP project codes are identical. The link is established for the upcoming fiscal year in the table given at the end of this document.

It should be noted that PREP projects are reviewed and planned by calendar year, while financial aspects are based on the fiscal year (April 1 to March 31). This is because the annual review and planning processes at the project level must be largely conducted during the fourth quarter (October-December) to meet higher level (e.g., national) timetables. The review, referenced to the goals set the previous year, can then be made on an entire year's work, and can be coordinated with Research Scientists' appraisals, also conducted by calendar year. Plans are by nature somewhat less precise than reviews, particularly when they must deal with the contingencies of scientific inquiry and fisheries management. Since calendar year and fiscal year overlap by 75%, most Planning Year goal statements on project forms in this document can refer to either. They should, therefore, be considered preliminary since they may be refined as financial planning progresses. Any significant changes in goals, however, are highlighted the following year in the achievements statement following each Review Year goal, or in the "Other Achievements" section of each project.

It should also be noted that this document represents review and planning for Branch scientific, EDP and administrative activities only and omits, due to prohibitively large volume, other documentation which may be necessary for the purpose at hand. This document includes all projects under Work Activity 1.1.5, i.e., the Director, Biological Sciences Branch, CAPSAC, the Regional Science Director, and the Marine Assessment and Liaison Division.

If you wish additional documentation, please contact Dr. M. Sinclair, Director, Biological Sciences Branch, Scotia-Fundy Region, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, N.S., B2Y 4A2. It includes:

- Responsible Manager's and Accountable Manager's Work Plans;
- Detailed budgets and spending summaries at various organizational levels;
- vessel schedules;
- collected Branch publications - these are given separately for each project in this document;
- Branch organization, mandate, and program descriptions. This information is provided in a document entitled, "Biological Sciences Branch, Scotia-Fundy Region - Structure and Functions", also known as the "Greenbook".

**PAS ROLL-UP NARRATIVES FOR 1991**

**Work Activity 1.1.1.1 Diadromous and Freshwater Fish**

Conservation levels and preliminary estimates of future surpluses for 18 Scotia-Fundy rivers (including a stock assessment for the upper Saint John River) were vetted at CAPSAC; requirements for advice increased in 1991 as a result of enhanced demands by Native Communities to broaden their food fishing activities. Staff participated in and provided CAPSAC and other advice to five Zone Management Committees, Area Managers and Canada-U.S. boundary water committees and interest groups. Numerous in-season forecasts of end-of-season projected counts were provided for Mactaquac, and staff advised managers during various and more frequent salmon allocation negotiations for Native food fisheries. They also advised and cooperated with numerous sport fishing associations, Indian Bands, corporations, commissions, steering committees, and other agencies in the execution of various assessment-related projects. The two-year adult salmon tracking study on the Saint John River was completed. Direction and assistance was provided to the fish culture program in the collection of 20 broodstocks, upriver distribution of 12,000 Saint John adult salmon, and distribution of over two million juvenile salmon. The collection of tag recovery information (salmon) and of sport and/or commercial catch statistics on several anadromous species continued, and assessments of the data were provided to users as required. All goals in connection with the enumeration, assessment and control of the spawning escapement of gaspereau returning to the Saint John River, Mactaquac Dam, were achieved. A three-year management plan for target spawning escapements of gaspereau at Mactaquac Dam was proposed and agreed to by the Minister. Assessments of the downstream movement of juvenile alewife and blueback herring from above Mactaquac Dam, and run timing of American eel elvers to the East River, Sheet Harbour, continued. Advice was provided on the Region's striped bass stocks and toward a new management regime for this weakened resource. An increasing number of requests for biological and technical advice on the non-salmonid diadromous species were effectively handled for internal and public sector clients.

8L  
103  
FS4  
716  
1991-2

#### Work Activity 1.1.1.2 Groundfish

As required by CAPSAC and NAFO, nine resource assessments of the Region's groundfish stocks (cod, haddock, pollock, silver hake and halibut) were conducted. The majority of these again employed the new-calibration method, ADAPT, developed in 1988/89 by MFD, which has revolutionized the zonal assessment process. However, it was evident that the previously noted problems with input data are causing problems with some stocks, particularly with 4TVWX haddock and 4VSW cod. This points to the importance of reliable input data and further emphasizes the need for science-industry cooperation. Commercial sampling activity both dock-side and side-board was carried out as planned. Extensive survey initiatives were also completed, including three standard bottom-trawl surveys, a deep sea exploratory cruise, a gear selection study, and inshore surveys in 4VWX, all as planned. Work on the efficient designs and use of these surveys in resource evaluation continued. The evaluation of acoustic hardware for surveys was completed. Research focused on the stock-I.D. and migration of a number of shelf populations, initiation of the Georges Bank program and further studies on 4VSW cod.

As a consequence of the Scotia-Fundy Groundfish Task Force, resources under AFAP were made available to enhance particular groundfish programs, including industry cooperation, survey improvement, distribution studies, harvest effects and communications.

#### Work Activity 1.1.1.3 Aquatic Invertebrates

The objectives under this PAS were generally achieved. Stock assessments for clam, scallop, and lobster fisheries were carried out for the Bay of Fundy area as planned. Communications with the industry were maintained through meetings, workshops, and newsletters. Survey work was also undertaken to examine lobster and scallop distribution in the vicinity of potential aquaculture sites. Clam enhancement studies in Passamaquoddy Bay were accomplished through volunteer efforts by fishermen, as expected funds did not materialize. A study on the seasonal development of sea urchin roe was initiated. The following goals were not achieved due to shortages of funds and/or manpower: aerial surveys of clam digging effort; tagging studies on the movement patterns of Bay of Fundy lobsters; a study on size-at-maturity in lobsters from Grand Manan; completion of a manual on lobster storage. A study to investigate selectivity and bottom impacts of Digby scallop drags was cancelled due to mechanical problems on the J.L. HART. Construction of laboratory facilities for behavioral studies of lobster was deferred due to the extensive field schedule. Testing of ROV and side-scan sonar techniques were not undertaken due to lack of suitable equipment.

Biological advice was provided on the status of all invertebrate units/stocks. Personnel were involved in numerous direct contacts with fishermen, attending about 20 advisory meetings, analyzing over 250 logbooks and participating in more than 50 trips on fishing vessels. The fishery was described, the resource surveyed and the biological advice given to resource management personnel for each management unit fledgling, including Scotian Shelf shrimp, which was fished after a long hiatus, and the sea urchin fishery. Long-term research was proposed for the northern Gulf of Maine lobster stocks. This work will attempt to discern the degree of mixing amongst these stocks. Little progress was made on the publishing of a backlog of data on larval lobster ecology, although one study suggested that larval residence time in a Scotian Shelf bay was short. A prototype post-larval lobster collector was assessed and a cage study demonstrated that newly molted, mature female lobsters, unattended by males, are cannibalized by dominant females. A mini-symposium on current topics in lobster resource science was organized and a draft report was submitted on a workshop organized to document our understanding of northern Gulf of Maine lobster ecology. Trial use by fishermen of an innovative claw gauge to identify morphometrically mature snow crabs was instituted.

Sea scallop larval distribution in the northern Gulf of Maine was described in relation to offshore banks and the Georges Bank frontal zone. Similar studies documented the distribution of juvenile scallops on this Bank in relation to both substrate types and other invertebrate species. RNA/DNA ratios were used to measure the year-round health of Bay of Fundy scallops; studies on gene sequencing in local commercial molluscs continued. The impact of scallop dragging on commercial lobster stocks was documented, but neither the scallop atlas project nor the morphometric analysis of scallop shells were completed.

#### Work Activity 1.1.1.4 Marine Mammals

Field programs included grey seal production estimates on Sable Island and the harbour seal survey in the Bay of Fundy. The seal energetics program concentrated on examination of growth process during the first year of life. These programs were executed as planned. In addition, AFAP resources allowed revitalization of the SSEP and SWIP programs and thus provide some assurances that the objectives of the five-year program will be met.

#### Work Activity 1.1.1.5 Marine Plants

The MOU between the Gulf and Scotia-Fundy Regions continued. Numerous fishery meetings were attended, all of which demonstrated considerable support for the program. Fishermen and companies offered logistic help and all three Maritime provincial governments assisted with some monetary support. Studies documented the invasion of Furcellaria (a seaweed of small commercial value) into western P.E.I. commercial Irish moss beds. Long-term studies were initiated to follow the competition between these two species under harvested and non-harvested conditions. This included the placement of a prototype structure, developed to preclude Irish moss dragrakes from small portions of commercial beds. In the Bay of Fundy, rockweed biomass was described using both land based and satellite techniques. Rockweed harvest strategy studies continued in southwestern N.S. A PDF, partially funded by industry, with considerable modelling experience has been added to this unit.

#### Work Activity 1.1.1.6 Pelagic Fishes

Assessments of the 4Vn, 4WX and 5Ze herring population were conducted as required by CAPSAC. The assessment for the largest resource (4WX) employed the ADAPT methodology. The Georges Bank evaluation was the first conducted on this resource since the days of ICNAF. Assessment research on swordfish and tuna continued, and the results were presented at ICCAT. Commercial sampling at the required levels was conducted in support of these activities. A number of survey initiatives were successfully completed, including larval surveys in the Bay of Fundy and on Georges Banks, and an acoustic survey in Sydney Bight. In addition, a summer acoustic survey was conducted in 4X to investigate an alternative to the 4Vn winter survey. The purse seine log book program continued. All activities progressed as planned.

The program on Georges Banks documented the continuing recovery of the potentially large herring resource. As well, a research program was defined for this stock. A second tagging study on bluefin tuna was conducted in 4X. This method is showing promise for the evaluation of this resource.

#### **Work Activity 1.1.1.7 Freshwater/Marine Ecology**

Studies on adult fish involved analysis of existing data on distribution in relation to physical environment and ecosystem size-dependent production processes. This work has received broad attention and was influential in the establishment of a long-term ocean monitoring program by PCSB using AFAP resources. Investigations of the sealworm population dynamics continues to concentrate on a description of coast-wide finfish infection rates and the life history of the benthic and epibenthic macrofauna.

Maintenance of the Divisional oceanographic program continued. However, budget constraints are requiring a re-examination of objectives.

Regarding EDP, at BIO it was announced that the CYBER would be replaced by 1 April 1993; this after an extensive NOS to NOS/VE conversion process. Plans were immediately initiated to become independent of the central facility. At St. Andrews, a decision was made to adopt PC-based graphics packages.

#### **Work Activity 1.1.1.8 Biological Oceanography/Limnology**

JGOFS (Joint Global Ocean Flux Study) research continued to play a dominant role in 1991 divisional activities. A major cruise was undertaken in April to study micro-scale turbulence and the optical properties of the ocean. Measurements for the first time were made on spectral light associated with pigment from a wide variety of water types. The phytoplankton had a strong influence on the spectral shape of both down and upwelling light. These studies are part of a program to remotely detect different phytoplankton species and plant biomass from space.

Studies on bacterioplankton and ultraphytoplankton (less than 10  $\mu\text{m}$ ) indicated that the bacteria play an important role during the annual spring bloom of phytoplankton in the western North Atlantic. Estimates showed a demand for primary production by bacteria of up to 78% in the upper 100m of the water column.

New methods were developed to separate phaeopigments (break down products of chlorophyll a) produced by copepod grazing or by cell autolysis. These important findings help to elucidate the contributions of algal die-off and copepod grazing to the sedimenting carbon flux in the ocean.

In collaboration with Metrology, PCS, a new study was initiated to study the long-term effects of temperature change on the community structure and production of zooplankton in Emerald Basin on the Scotia Shelf. The Basin is believed to reflect temperatures on the entire shelf. Temperature changes over the last two decades have been associated with major changes in zooplankton species composition. These changes in turn may be influencing changes in the fish community. New sampling techniques using acoustics and lights associated with nets have resulted in more accurate models for acoustic backscattering for krill.

Arctic studies on phytoplankton and zooplankton showed that Arctic copepods live twice as long as the same species in warmer temperate waters.

#### **Work Activity 1.1.2.1 and 1.1.2.3 Fish Health; Nutrition and Feed Technology**

Biological advice on disease, parasites, nutrition and invertebrate culture was provided to numerous agencies and commercial interests. Fish Health Unit personnel issued 53 import permits, carried out 108 inspections, provided diagnostics for 156 transfers, and investigated 30 wild fish kills. No major disease outbreaks were recorded at federal fish hatcheries, but typical furunculosis was diagnosed at three Bay of Fundy salmon cage sites. Significant input was provided to both the revisions to the FHPR and the aquaculture sector plans of the N.S. provincial government. The 14th Fish Health Workshop was organized, attracting 150 scientific personnel and industry representatives. The efficacy of numerous furunculosis diagnostic methods was determined and more than 100 strains of *Aeromonas salmonicida* were bacteriophage-typed. Finfish nutrition accomplishments included the development and formal inter-divisional review of a long-term research proposal which will provide the basis for a scientist's shift in research from crustacean nutrition to lipid research of groundfish species with high aquaculture potential. The vitamin B6 requirements for Atlantic salmon on artificial feeds was discerned, and it was discovered that folic acid does not enhance immunity to furunculosis. The nutritional value of 25 commercial fish feeds was determined. Depuration rates were documented for various levels of domoic acid, concentrated in both laboratory-held mussels and one wild-infected population.

#### **Work Activity 1.1.2.2 Genetics, Physiology, Endocrinology**

The objectives under this PAS were generally achieved. Research on production of under-yearling smolts, reduction of grilse maturation, and transgenics was performed in conjunction with industry and university scientists. A proposed investigation on the use of spotted fins as a natural genetic marker was not undertaken due to lack of lab space and funds. The Salmon Genetics Research Program continued to conduct research and development in the genetics of salmon strains used in release-return and cage culture. The initiation of a study on larval halibut survival was limited, due to delays in receiving incubators, and a lack of eggs. However, on-growing studies of halibut in modified salmon cages indicated that this aspect of halibut culture is economically feasible in the Bay of Fundy. Studies proceeded on striped bass culture, growth of eel elvers, sex reversal in lumpfish, molting and spawning of lobster, and the feasibility of scallop culture.

#### **Work Activity 1.1.2.4 Fish Production Systems**

Appropriate field activities were undertaken on the LaHave and Liscomb Rivers to continue salmon enhancement project evaluations; this information base was used to develop Regional stock status reports and assessments which appear in CAFSAC documentation. Participation in the development of the Atlantic salmon and gaspereau resources of the St. Croix River continued with the monitoring of runs. Production and release of juvenile Atlantic salmon to public waters comprised 105,000 salmon fry, 775,000 parr and 755,000 smolts; 72,000 smolts were also supplied to the aquaculture industry for broodstock development programs in Nova Scotia and New Brunswick and for research purposes to the Salmon Demonstration and

Development Farm in New Brunswick. In conjunction with Native communities, initiated and/or planned the establishment of Native food fisheries dependent on hatchery stocking. High priority was given to maintaining the high quality of hatchery smolts; to this end, considerable improvements were made to the ponds at Mactaquac, Saint John and Cobeguid Hatcheries. Public awareness activities included the opening of the Mactaquac Visitor Centre, invited assistance by various recreational fisheries associations and elementary school classes in the distribution of hatchery fish, and the publication and distribution of information about the activities of DFO hatcheries. Planning was completed for engineering projects to develop or improve fish passage and fish culture facilities in the Region; engineering project administration and site supervision were carried out on several projects. Engineering advice was supplied to Fisheries and Habitat Management Branch, industry and the public on fish passage design, water intake or discharge screening devices and in regard to habitat improvement or alterations.

#### **Work Activity 1.1.3.1 Impact of Physical Changes**

A draft Initial Environmental Assessment (IEA) was prepared for the proposed fish passage facility at Grand Falls, Saint John River. A review of the IEA for the hydroelectric project on the LaHave River was completed. IEAS were also prepared for ten other water use projects. Advice was provided on a contract let by DFO to assess the fisheries enhancement potential of the Madawaska River, for eight liming projects, on the effects of water quality in MacKintosh Run, on the regulation of water levels in the St. Croix River to protect fish habitat, on the suitability of urban lakes for trout stocking and/or natural production, and on the fisheries resources in the vicinity of all existing military bases in Scotia-Fundy. Fish kills were investigated on Nine Mile River and Fall River. Analysis has been completed and a draft manuscript prepared on micro-habitat availability, egg deposition and electrofishing densities of juvenile salmon on the Tobique River. Investigations continued into the practicality of integrating the LaHave River salmon management model with a GIS.

Monitoring of the recruitment of juvenile soft-shell clams to previously depopulated areas of the Annapolis Basin indicates a general recovery of stocks. Although reduced in size, the clam enhancement project continued to provide new data which will improve the management of this important inshore fishery. Zooplankton habitat data from previous studies have been analyzed and published. Advice was provided on the status and condition of the harbour porpoise population in the Bay of Fundy. New data on bioenergetic processes in fish production are being obtained through the Ocean Production Enhancement Network (OPEN) program. In collaboration with other agencies, a start has been made in developing a marine habitat sensitivity data base using a geographic information system (GIS). A research cruise to Georges Bank documented the abundance and distribution of ghost nets. A research cruise to the Grand Banks and Western Bank surveyed sites that have been selected for future experiments to determine the ecological effects of sea-floor disturbance by mobile fishing. Experiments on the effects of mobile fishing gear on the intertidal sands flats of the Minas Basin were completed.

#### **Work Activity 1.1.3.2 Aquatic Pollutant Assessment**

The LRTAP program achieved its objectives, despite the uncertainty of year-round technical assistance. Research continued on ecological and physiological effects of acid deposition on salmonids and on mitigation of low pH effects in salmon streams. The scientist-in-charge continued duties as coordinator of the Scotia-Fundy LRTAP program and as representative on the DFO LRTAP Subcommittee. Project 407 has been terminated, except for publishing of some results.

This research is to support Canadian claims to the United States regarding the extent of adverse impacts of acid precipitation on Canadian freshwater ecosystems, especially Atlantic salmon populations. The biomonitoring program was subjected to peer review and restructured to accommodate both Regional and National objectives; consistent with the revised design, fish and benthic invertebrate communities were sampled once during the year in the three lakes within the Kejimikujik National Park and monitoring was carried out on six rivers of varying pH for chemistry (monthly), benthic invertebrates (twice yearly) and fish (yearly). Fish bioassays were completed on four rivers; this was the final year of the fish bioassay monitor. The lake liming and biological/chemical monitoring program of the demonstration deacidified refuge in East River, Chester, N.S., was continued for the sixth year; this year's lime application was reduced to 200 tonnes, consistent with the recommendation from a peer review of this project. Further progress was made on model development for assessing the effects of varying acidity due to acid rain on salmon production; a contract has been let to revise the two biological submodels and to program the hydrochemical submodel. Analysis has been completed on twenty years of presence/absence data for N.S. lake fish species, and the relation between disappearance of species and levels of acidity; a report is in preparation. A national benthic invertebrate species list was developed for the biomonitoring data base, and the list has been computerized.

A major review on marine toxins is in the final stages of preparation. Substantial progress has been made in understanding the role of bacteria in the production of phycotoxins. Advances have been made in understanding the physiology of domoic acid production by *Nitzschia pungens*. A three-year phytoplankton monitoring program with stations at five coastal locations around Nova Scotia was completed and all data entered into a database management system.

Laboratory experiments using flumes to simulate flow conditions on Georges Bank continued to indicate that sea scallops are very sensitive to low concentrations of suspended clay particles. A research cruise to Georges Bank obtained data on the concentration and size distribution of naturally occurring particles just above the sea floor which constitute the food source for scallops. Studies on the flux of contaminants between sediments and the water column of Halifax Harbour continued, as well as collaborative studies on the sublethal effects of contaminated Harbour sediments on selected benthic organisms. Sediment trap samples collected previously under the Canadian Ice Island were analyzed.

#### **Work Activity 1.1.3.3 Harmful Marine Algae**

The objectives under this PAS were generally achieved. The phytoplankton bloom dynamics monitoring project continued with regular sampling of four stations and a new project was initiated to determine the factors controlling domoic acid production in *Nitzschia pseudodelicatissima*. Tests were initiated on an automated flume for studying bivalves feeding on toxic microalgae. Research on screening bioassays involving salmon open-heart ECGs has been abandoned due to difficulties in obtaining repeatable results; work on use of implanted acoustic heart tags is planned.

### **Work Activity 1.1.3.5 Environmental Impact of Aquaculture**

The objectives under this PAS, including studies on bivalve feeding and the environmental effects of salmon aquaculture, have been achieved. A collaborative project, with the Habitat Ecology Division, on microbial ecology of salmon cage sites was cancelled when the selected PDF candidate obtained work elsewhere and funds were not received. Testing of different techniques for measuring filtration rates of scallops has resulted in discarding of some methods and further testing of other methods.

Field programs continued to collect data on the effects on the water column and sediments of salmon aquaculture in the L'Etang Inlet of southwestern New Brunswick. Substantial progress was made on computer models that can be used by both scientists and managers to help predict the possible impacts of future expansion by the industry. A workshop was held to inform DFO and provincial managers of progress made.

### **DIVISIONAL HIGHLIGHTS**

#### **MARINE FISH DIVISION**

The Division provided nine groundfish, two herring, one swordfish and one tuna stock assessment through CAFSAC, NAFO, and ICCAT and worked extensively with various industry management groups. The cooperative research program with industry is gaining support and is proving a successful endeavour. The annual FINS process has evolved into one-on-one Science/fishing association meetings and annual attendance at fisheries exhibitions.

The Division produced 20 primary publications, two interpretive scientific papers, 46 scientific and technical reports and five popular and miscellaneous articles. Of particular note are reports providing the scientific basis for recent regulatory changes in the groundfish fisheries.

The seal program continues to concentrate on the dynamics of seal/sealworm/fish interactions. Studies on the efficacy of ivermectin, a sealworm vaccine and birth control agents continued. The latter is showing particular promise in the control of seal populations.

The herring program conducted extensive survey coverage of Georges Bank and further documented the recovery of the resident population. It is still uncertain when commercial exploitation can resume. Industry is becoming increasingly aware of the potential of this resource. Plans were made for a science/industry cooperative research study in 1992 to allow finer definition of the spawning grounds and thus facilitate stock monitoring by surveys.

The swordfish program continues as planned. As well, a second tuna tagging study was conducted. This method is showing promise for abundance determinations.

The Division continues to suffer a diminishing A-Base budget, both of O&M and Capital, along with increased external demands on staff. The impact of some of the decline in A-Base resources has been mitigated by funding received under AFAP. However, the latter are targeted at particular programs and are of short duration. Indeed, much of this funding was recalled. Currently almost 70% of the A-Base budget is dedicated to non-discretionary requirements. Research is becoming increasingly dependent on B-Base funding, a situation which makes long-term planning difficult.

#### **BENTHIC FISHERIES AND AQUACULTURE DIVISION**

During 1991, Division personnel wrote 13 primary publications, 16 technical reports, edited two international newsletters (lobsters and crustacean nutrition), presented results at 30 conferences/workshops, interpreted biological advice for fishery advisory committees, dealt with numerous queries from the public and news agencies, interacted with university and provincial government personnel, manned science booths at industry fairs and assisted international development agencies. Key work was published on sea scallop ecology and salmon disease and nutrition. Publication numbers were down from previous years with a number of scientists not meeting their goals. This was due to other program priorities such as design and construction of the E.M. room, made necessary by the acquisition of a new Scanning E.M., and additional accomplishments which will lead to publications. The demand for biological advice and involvement with invertebrate fisheries was not excessive although demand for marine plant biological advice continued to grow, as did the demand for finfish nutrition and disease advice and disease diagnostic service. The Divisional budget was hard pressed in providing a PDF for the understaffed Disease Research Unit. Two Visiting Scientists, five graduate students and two Honours B.Sc. students added new insights to Division projects.

The laboratory's LAN system was integrated into the regional WAN system and considerable time was invested in training personnel in ORACLE and NOS/VE. ACON was equipped with 3D visualization. The Division again provided the chairperson of the Branch Computer Committee and the Regional Diving Officer. The addition of a staff mathematician provided ready access to statistical and experimental design advice. Experienced personnel in both crab research and disease diagnostics were lost, and there was a 3.5% reduction to the Division's FTC PY allotment. Some research monies were diverted to laboratory upgrading, construction of an electron microscope suite and a new biocide system for the quarantine unit. O&M and overtime funds were tight and unless enhanced will require a change in the way the Division meets mandates. Scientific staff now volunteer labour for building and grounds upkeep and the provision of small amenities. Laboratory personnel organized and solicited outside funds for a 'touch tank' situated on the boardwalk, which provided information on marine biology and resource science to about 80,000 observers. A mid-year review for all projects was again held and staff meetings were commonplace.

#### **FRESHWATER AND ANADROMOUS DIVISION**

Salmon assessment advice was provided more frequently during the year and for an increased number of stocks as a result of increased demands by Native communities to broaden their food fishing activities. Most significant occurrences among salmon stocks were the fifth recruitment failure in the past six years in the inner Bay of Fundy stocks, failure again to achieve the spawning escapement target for the Saint John River above Mactaquac, and lower than average/forecast returns of 1SW salmon to rivers. Returns of gaspereau (alewife and blueback herring) to the Saint John and St. Croix rivers were, for the second

consecutive year, considerably lower than expected. Results from a two-year adult salmon tracking study, carried out in collaboration with the N.B. Power, the N.B. Department of Natural Resources and Energy, local angling associations and the Tobique Indian Band were adequate to convince N.B. Power to initiate, in 1992, the first phase of a DFO plan to upgrade fish passage at Beechwood Dam. A three-year harvest plan for Mactaquac gaspereau was recommended and approved by the Minister. Advice was provided on the Region's striped bass stocks and toward a new management regime for this weakened resource. The salmon stock assessment program was subjected to peer review which gave the program a favourable report.

Atlantic salmon production targets were met at the five Division hatcheries operated in 1991/92 and in total approached 2.0 million fish. Yarmouth Hatchery was not operated during the year and is under consideration for closure as a cost saving measure. The hatchery production was used in various enhancement and maintenance stocking projects under which salmon juveniles were distributed to twenty-five rivers in N.S. and N.B. Smolts were also provided to support aquaculture in the form of broodstock development programs in both provinces, research at the N.B. Salmon Demonstration and Development Farm and aid to the N.B. industry (50,000 smolts) to help cover-off a shortfall due to disease. Fifty thousand salmon eggs were provided for the fifth year to the Ontario government in support of the restoration of Atlantic salmon to Lake Ontario. Plans are being made to develop, and in some instances redirect, hatchery stocking programs toward the support of Native food fisheries.

Further progress was made toward increasing public awareness of ongoing programs by securing the involvement of more public interest groups in the planning and operation of field projects, including the participation of school children and public groups in stocking hatchery salmon, and through the preparation and distribution of information about the Division's hatchery programs. The Visitor Centre at Mactaquac Hatchery was completed and officially opened in June.

Bio-engineering technical reviews of several private salmon hatchery proposals were carried out in support of commercial salmon hatchery development. Functional design and construction and operation cost estimates were provided to the Eskasoni Indian Band for the development of a small hatchery on the reserve. Maintenance and construction projects were carried out at all hatcheries and a number of fish passage facilities. Engineering design was completed for habitat improvement projects and advice on fish passage was provided to outside agencies and industry (e.g., the public hydro utilities, Irving Ltd., Georgia-Pacific Inc.). Design work on fish passage facilities for Grand Falls, Saint John River, is progressing, but awaits input from a geological-engineering study of the falls. Scientific advice was provided on a variety of projects relating to fish habitat protection including small hydro developments proposed for the LaHave and West Rivers, Sheet Harbour, N.S.

Both the LRTAP biomonitoring program and the lake liming mitigation research programs were streamlined and otherwise changed to encompass Regional interests in accordance with a peer review of these projects. Model development for assessing the effects of various acidity levels on Atlantic salmon production capability is progressing favourably. Requests for advice, encompassing the full range of freshwater dependent species, increased as a result of new demands for Indian food fisheries, growing interest in implementing river-specific management of salmon stocks, increased demands for environmental assessment and enhanced requirements for a number of species that previously received less attention (e.g., striped bass, American eel).

#### **AQUACULTURE AND INVERTEBRATE FISHERIES DIVISION**

Research on the physiology and genetics of salmon in sea cages included: ongoing studies on the production of underyearling salmon smolts; the initiation of a study (with industry cooperation) to reduce maturation as grilse in sea cage salmon; participation in a NSERC Strategic Grant Project examining transgenic salmon with added growth hormone; continued research with the Atlantic Salmon Federation through the Salmon Genetics Research Program on the selection of strains involved in release-return and cage culture stocks. Studies on halibut culture in a modified salmon cage (in cooperation with a local salmon grower) indicated that on-growing of halibut is economically feasible. Other halibut research included the initiation of a study on the effects of salinity and flow rate on halibut egg fertilization and early development. Research on other candidate aquaculture species included: the initiation of a study on the culture of haddock in a modified salmon cage (in cooperation with a local salmon grower); the successful production of viable eggs from captive striped bass broodstock; the determination of optimal temperatures for growth of eel elvers; the successful incorporation of estrogen into *artemia*, which will be fed to larval lumpfish in a sex reversal study; studies on factors affecting molting and spawning of lobster; and studies on the feasibility of scallop culture. Transfer of scientific and technical information on aquaculture was facilitated through editing and publishing of World Aquaculture and the Proceedings of the Aquaculture Association of Canada annual meeting, workshops, meetings, and support of the Atlantic Salmon Demonstration and Development Farm.

Monitoring of the dynamics of phytoplankton blooms in the Bay of Fundy continued. A project was initiated on the factors controlling domoic acid production in *Nitzschia pseudodelicatissima*.

Studies continued, in collaboration with the University of New Brunswick, on the environmental factors affecting bivalve feeding rates. Studies also continued, in collaboration with the Habitat Ecology Division, on the effects of salmon mariculture on the benthos and water column; a goal of this project is the development of a holding capacity model for the salmon culture industry in the L'Etang area.

The scientist-in-charge of the St. Andrews LRTAP program continued in his role as coordinator of the Scotia-Fundy LRTAP program and served on the DFO LRTAP Subcommittee. Studies continued on the effects of liming on chemistry and fish in acidic streams. A study was completed on the effects of complex solutions of aluminum, silicon, and citrate under acidic conditions on salmon fry survival and physiology.

The Invertebrate Fisheries Section is responsible for stock assessments for clam, scallop, and lobster fisheries in the Bay of Fundy area. Research carried out under this mandate included: continuing studies on spatfall and growth rates of soft-shell clam in southwestern New Brunswick, in cooperation with local fishermen; population surveys, and studies on growth and mortality rates of clam populations; assessment and spat surveys for Bay of Fundy scallops; monitoring of the Bay of Fundy lobster fishery; surveys of juvenile and mature lobster distributions; studies on the interaction between salmon aquaculture and the lobster fishery; initiation of a study on the environmental requirements of a parasite affecting lobsters in holding facilities; initiation of an exploratory study on sea urchins.

## BIOLOGICAL OCEANOGRAPHY DIVISION

Much of the Biological Oceanography Division's efforts were directed toward the analysis and interpretation of data collected during the International Joint Global Ocean Flux Study (JGOFS) cruise during the spring phytoplankton bloom in 1989. Members of the Division, representing Canada, attended a JGOFS Symposium in Washington, D.C. Results of this work will be published in a special issue of Deep-Sea Research in 1992. An additional JGOFS cruise was carried out in 1991; analysis of results from past expeditions continued during the review period. Coordination planning was initiated for subsequent JGOFS studies in the North Atlantic with the next major international field effort planned for 1996/97.

Analysis of the 1988 Georges Bank data progressed and the latest results were presented at the ALSO meeting in Halifax during June. It was found that there were strong seasonal variations in the intensity of vertical mixing, and thus nitrate flux, on Georges Bank which were strongly affected by the stratification. Our increased understanding of the mixing processes on Georges Bank should soon allow these processes, and the primary production they drive, to be modelled. During the 1991 WOCE cruise, the spectral irradiance meter developed by the Division collected data for the first time. Spectral light data and associated pigment data from water samples were collected in a wide variety of water types over the North West Atlantic. The data show a strong influence of phytoplankton on the spectral shape and magnitude of peaks in upwelling and downwelling spectra. It is thus possible that the spectral signatures of different phytoplankton species will eventually be sensed remotely with production and species composition, as well as biomass, determined from space.

New insights were obtained on the relative importance of bacterioplankton and ultraphytoplankton (i.e. cyanobacteria, prochlorophytes, eukaryotic nanoplankters) in various oceanic regimes. An analysis of conditions in the oligotrophic Sargasso Sea in summer indicated co-dominance in biomass of these two trophic groups. Observations contrast with findings published by others and our interpretation admits the possibility that oligotrophic bacteria may have growth rates higher than prescribed under different assumptions. A similar analysis of conditions occurring during the 1989 spring bloom in the western North Atlantic (JGOFS) indicated the significant role played by bacteria during the annual period of rapid phytoplankton growth. Our measurements and assumptions implied a bacterial demand for primary production on the order of 24-78% over the upper 100 m of the water column.

New work was initiated to explore the use of flow cytometry to assess rates of primary production. This includes laboratory and field work utilizing a fluorescence induction method and a cell sorting method. Preliminary results are promising, but the general objective of determining rates of bulk primary production using flow cytometry will not be met in the near future.

Detailed pigment analysis (by HPLC) of material from the 1990 JGOFS cruise showed that algal chlorophyll *a* may be converted into phaeopigments *in situ* either by cell autolysis or during grazing by copepods. The phaeopigments produced by the two processes were apparently different and both accumulated in sediment traps. Thus HPLC pigment analysis can help elucidate the contributions of algal die-off and copepod grazing to sedimenting carbon flux in the ocean.

HPLC analysis of pigments has also shown that in experiments where diatoms are fed to copepods, chlorophyll *a* conversion into phaeopigments is not generally quantitative and that chlorophyll *c* and the carotenoids fucoxanthin and diadinoxanthin are largely destroyed during grazing.

Studies were started on the effects of increased ocean temperature, due to global warming, on the species composition and production of copepods on the Nova Scotia Shelf. A moored zooplankton counter located in Emerald Basin will provide year long time series data on changes in the population size and species composition of *Calanus*, the most important copepod genus. These data will be supplemented by extensive net sampling of the zooplankton populations. In recent years large temperature changes have been observed in Emerald Basin and in other basins on the shelf which have been associated with major changes in the zooplankton populations. It is hypothesized that these temperature and zooplankton changes may be related to major shifts in the species composition of the fish communities on the shelf.

The *M.V. Arctic*, an ice-breaking bulk carrier normally used to transport heavy-metal concentrate from Canada's Arctic mines, was used as a "ship of opportunity" to sample the North Water polynya in northern Baffin Bay in May, about two months earlier than any previous shipboard observations in the area. The growth of plant and animal plankton was well advanced, suggesting that such ice-free "oases" may accelerate Arctic production by at least two months.

## HABITAT ECOLOGY DIVISION

Divisional staff effectively responded to all client requests, both within and external to DFO, for habitat advice by serving on a large number of committees, reviewing various documents, filling information requests, conducting field surveys, presenting lectures, giving media interviews, and attending a large number of meetings and workshops. The Division continued close collaboration with other Science Sector Divisions and the Habitat Management Branch on both research and the provision of habitat advice.

The basis of the habitat science program is a broad range of applied and basic research projects that provide new information that can be used to help resolve important habitat issues facing DFO, both today and in the future. During 1991, research efforts addressed marine toxins, the environmental impacts of aquaculture, coastal zone monitoring, inshore clam habitat management, impact of drilling wastes on scallops, zooplankton and benthic habitat on the continental shelf, benthic/pelagic exchanges, fish and marine mammal habitat interactions, contaminants in Halifax Harbour, atmospherically transported organic contaminants, habitat sensitivity mapping, development of benthic sampling gear, and the impacts of ghost nets and mobile fishing gear on marine habitat. The Division has been successful in obtaining additional research funding from the Atlantic Fisheries Adjustment Program (AFAP), the Panel on Energy Research and Development (PERD), and the Green Plan. Increased priority continues to be given to coastal zone studies - in particular, research on the environmental impacts of aquaculture.

Division staff continued to play important leadership roles in international scientific organizations and activities. They also have made significant contributions to national DFO activities, including program coordination. In addition, several staff maintained their university affiliations and received substantial funding through the Natural Sciences and Engineering Research Council of Canada (NSERC).

Due to dwindling resources, both financial and personnel, it continues to be difficult to maintain a credible habitat science program which adequately addresses important Departmental environmental priorities. The Division has been successful in obtaining some B-Base funding, but it must be used to address specific issues of today and therefore does not assist longer-term research which will help the Division respond effectively to the issues of tomorrow. The call-back of AFAP funds and the January "freeze" on spending seriously disturbed programs, reduced staff morale, and diverted time from scientific activities. In the long term, the most serious problem is with personnel. The non-scientific workload for most staff is increasing, which cuts into scientific productivity. No new scientist staff have been hired for a decade, and fresh scientific blood is urgently required. The Division lost another scientist through early retirement, and he was not replaced. If the present trend continues, the ability of the Division to provide sound scientific advice on habitat issues will be seriously eroded. This expertise cannot be rebuilt overnight, even with unlimited resources. Another problem faced is the continued erosion of basic scientific support facilities such as libraries, machine shops, and the Fish Laboratory.

5900-0000	Regional Director, Science Sector MacPhee, S.B. . . . .	1
5910-0000	Director, Biological Sciences Branch Sinclair, M. . . . .	3
5901-0000 to 5907-0000	Marine Assessment & Liaison Nicholls, H.B. . . . .	5
5518-0000 to 5522	Biological Sciences Ships Wheelhouse, J. . . . .	7
<b>MARINE FISH DIVISION</b>		
000	Division Administration O'Boyle, R. . . . .	10
1001	Herring Assessments and Associated Research (Subarea 4) Stephenson, R. . . . .	13
1005	Herring Assessment and Associated Research (Subarea 5) Melvin, G. . . . .	17
101	4TVW Haddock Assessment and Associated Research Zwanenburg, K. . . . .	20
1012	4X Haddock Assessments and Associated Research Hurley, P. . . . .	22
1013	Haddock Assessments and Associated Research 5Ze Gavaris, S. . . . .	25
1021	Cod Assessments and Associated Research in Subdivision 4Vn Lambert, T. . . . .	28
1022	Cod Assessments and Associated Research in Division 4Vsw Fanning, P. (1991) ; Mohn, R. (1992) . . . . .	30
1023	4X Cod Assessment and Associated Research Campana, S. . . . .	32
1024	5Z Cod Assessments and Associated Research Hunt, J. . . . .	34
103	Pollock Assessment and Associated Research Annand, C. . . . .	36
104	Silver Hake Assessments and Associated Research Waldron, D. . . . .	39
105	Redfish Assessments and Associated Research O'Boyle, R. . . . .	42
106	Flatfish Assessments and Associated Research Neilson, J.; Annand, C. . . . .	44
107	Continental Shelf Margin Studies Including Argentine Assessment Halliday, R. . . . .	47
108	Population Ecology of Sealworm McClelland, G. . . . .	49
1091	Seal Diet and Energetics Bowen, D. . . . .	52

1092	Seal Population Dynamics Stobo, W. . . . .	55
1093	Seal Research Infrastructure Bowen, D. . . . .	57
110	Groundfish Management Research Halliday, R. . . . .	59
112	National Sampling Program Zwanenburg, K. . . . .	62
113	International Observer Program Waldron, D. . . . .	65
1140	Groundfish Trawl Surveys Hunt, J. . . . .	68
1150	Groundfish Age Determination Hunt, J.; Annand, C. . . . .	70
117	Fisheries Recruitment Variability Frank, K. . . . .	73
118	Otolith Studies Campana, S. . . . .	76
119	Finfish Tagging Studies Stobo, W. . . . .	80
121	Ecosystem Size Processes Dickie, L. . . . .	82
122	Large Pelagics Assessment and Associated Research Porter, J. . . . .	84
123	Pelagic Acoustics Surveys Buerkle, U. . . . .	87
1250	Oceanography and Fish Distribution Page, F. . . . .	90
126	Juvenile Fish Ecology and Surveys Neilson, J. . . . .	94
127	Oceanographic Data Handling McRuer, J. (Collection); Page, F. (Processing) . . . . .	96
128	Pelagic Fisheries Management Studies Iles, D. . . . .	100
130	Reproductive Strategies of Marine Fish Lambert, T. . . . .	103
131	EDP Support Branton, R. . . . .	105
132	Statistical Research and Collaborative Studies Smith, S. . . . .	111
134	Stock Structure Studies Zwanenburg, K. . . . .	114
1350	Dynamics of Recruitment Processes for Gulf of Maine Gadids Trippel, E. . . . .	116

9765	Groundfish Ecosystem - Harvesting Data O'Boyle, R. . . . .	119
9766	Groundfish Ecosystems: Research Information-Survey Data Gavaris, S. . . . .	122
9767	Groundfish Ecosystems: Research Information - Geographic Distribution O'Boyle, R. . . . .	124
9769	Longliner Project - AFAP Halliday, R. . . . .	127
9771	Communications - Fishermen O'Boyle, R. . . . .	129
9813	Seal/Sealworm Ecology - Diet/Parasite Studies Bowen, D. . . . .	131
9814	Seal Population Monitoring Stobo, W. . . . .	133
<b>BENTHIC FISHERIES AND AQUACULTURE DIVISION</b>		
200	Informatics Swetnam, D. . . . .	136
201	Larval Ecology and Lobster Assessment (LFA 33) Tremblay, J. . . . .	139
202	Lobster Resource Science Hudon, C. . . . .	141
203	Scallop Assessment and Research Robert, G. . . . .	143
204	Offshore Clams Assessment and Research Roddick, D. . . . .	146
205	Scallop Research Kenchington, E. (nee Rice) . . . . .	148
206	Cape Breton Crustacean Assessment and Research Tremblay, J. . . . .	151
207	Marine Plants Assessment and Research Sharp, G. . . . .	153
208	Marine Plants Assessment and Research - Gulf Region Sharp, G. . . . .	155
210	Lobster Stock Assessment (LFA 40-41) and Related Research Pezzack, D. . . . .	157
211	Lobster Habitat Research and Assessment Methodology Miller, R.J. . . . .	159
212	Lobster Resource Science - Larval Biology Harding, G.C.; Pringle, J. . . . .	162
213	Lobster Resource Science and Assessment - LFA 31 and 32 Pringle, J. . . . .	164
214	Lobster Assessment and Related Research in LFA 34 Pezzack, D. . . . .	166

220	Statistical Consulting Rodger, R. . . . .	169
225	Section Administration Robert, G. . . . .	171
226	Division/Laboratory Administration Pringle, J. . . . .	173
229	Wild Mussel Resource Assessment and Research Sharp, G. . . . .	175
235	Resource Mapping and Special Projects Black, G. . . . .	177
241	Administration - Aquaculture Section Scarratt, D. . . . .	179
242	Invertebrate Nutrition Castell, J. . . . .	181
243	Fish Nutrition Lall, S. . . . .	184
244	Fish Disease Research Olivier, G. . . . .	187
245	Parasitology Morrison, C. . . . .	190
246	Molluscan Culture and Phytotoxin Research Scarratt, D. . . . .	192
247	Molluscan Nutrition Kean-Howie, J. . . . .	196
248	Fish Health Services Unit Cornick, J. . . . .	198
<b>FRESHWATER AND ANADROMOUS DIVISION</b>		
300	Division Administration Ritter, J. . . . .	203
301	Salmon Assessment Research Marshall, T. . . . .	205
302	Non-Salmonid Assessment Research Jessop, B. . . . .	210
303	Salmon Enhancement Research (Enhancement Biology) Cutting, R. . . . .	213
304	Enhancement and Fish Passage Engineering Jansen, H. . . . .	216
305	Fish Culture Engineering Jansen, H. . . . .	219
306	Finfish and Invertebrate Introductions and Transfers Cutting, R. . . . .	222
308	Hatchery Operations and Production Farmer, G. . . . .	224

309	Fish Culture Research Farmer, G. . . . .	227
310	Anadromous Species Statistical Consulting and Data Collection and Analysis O'Neil, S. . . . .	230
311	Divisional Informatics O'Neil, S. . . . .	232
315	Acid Rain Research Watt, W. . . . .	235
316	Freshwater Fish Habitat Assessment and Related Research Watt, W. . . . .	238
<b>AQUACULTURE AND INVERTEBRATE FISHERIES DIVISION</b>		
400	Coordination, Aquaculture and Invertebrate Fisheries Program Cook, R. . . . .	242
401	Salmon Genetics Research Program Cook, R. . . . .	245
402	Salmonid Growth, Smolting and Reproduction Saunders, R. . . . .	249
404	Phytotoxin Research Wildish, D. . . . .	252
405	Marine Finfish Aquaculture Waiwood, K. . . . .	255
406	Aquaculture Ecology Research Wildish, D. . . . .	258
407	Effects of Low pH on Salmonid Development Peterson, R. . . . .	261
408	Environmental Requirements for Early Fish Development Peterson, R. . . . .	263
409	Effects of Acid Rain Control Programs on Salmonid Recovery Lacroix, G. . . . .	266
410	Invertebrate Fisheries and Aquaculture Research Aiken, D. . . . .	269
411	Soft-Shell Clam Fishery Research Robinson, S. . . . .	272
412	Scallop Population Dynamics and Assessment Robinson, S. . . . .	275
413	Lobster Stock Assessment (LFA's 35, 36 and 38) Lawton, P. . . . .	278
414	Population Dynamics and Ecology of Bay of Fundy Lobsters Lawton, P. . . . .	281
415	Invertebrate Biology Waddy, S. . . . .	284
416	Resource Potential of Underutilized Invertebrate Species Robinson, S.; Lawton, P. . . . .	287

## ST. ANDREWS BIOLOGICAL STATION

500	Administration and Support Services Waiwood, B. . . . .	290
510	Computer Centre Waiwood, B. . . . .	292
520	S/V J.L. HART Waiwood, B. . . . .	294
530	S/V PANDALUS III Waiwood, B. . . . .	296
540	Atlantic Reference Centre Cook, R. (Scientific Authority); Sulak, K. (Huntsman Marine Science Centre) . . . . .	298
<b>BIOLOGICAL OCEANOGRAPHY DIVISION</b>		
600	Bio-Optical Properties of Pelagic Oceans Platt, T. . . . .	303
602	Respiration, Nutrient Uptake, Regeneration of Natural Plankton Populations Harrison, W. . . . .	305
603	Physical Oceanography of Selected Features in Connection with Marine Ecological Studies Horne, E. . . . .	308
604	Physiology of Marine Microorganisms Li, W. . . . .	310
607	Carbon Dioxide and Climate: Biogeochemical Cycles in the Ocean Platt, T. . . . .	312
608	Analysis of Pelagic Ecosystem Structure Longhurst, A. . . . .	314
609	Carbon and Nitrogen Utilization by Zooplankton and Factors Controlling Secondary Production Conover, R. . . . .	316
611	Secondary Production and the Dynamic Distribution of Micronekton in the Scotian Shelf Sameoto, D. . . . .	318
612	Biological Stratification in the Ocean and Global Carbon Flux Longhurst, A. . . . .	320
613	Nutrition and Biochemistry in Marine Zooplankton Head, E. . . . .	323
619	Shore-Based Studies of Under-Ice Epontic and Pelagic Plankton Communities Conover, R. . . . .	325
620	Summertime Shipboard Studies in the Eastern Canadian Arctic Head, E. . . . .	327
621	Dynamics of Microbial Metabolism and Particle Flux Kepkay, P. . . . .	329
622	Mathematical Models of Marine Pelagic Communities White, G. . . . .	332
624	Year Round Plankton Research in the Arctic Conover, R. . . . .	334

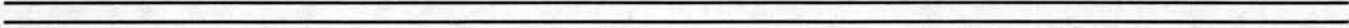
## HABITAT ECOLOGY DIVISION

000	Division Administration and Management Gordon, D.C. . . . .	337
700	Fish Habitat Assessment Advice Gordon, D.C. . . . .	339
701	Microbial Ecology Stewart, J.E. . . . .	341
702	Microbial-Marine Toxin Interactions Stewart, J.E. . . . .	344
703	Physiological Ecology of Toxic Algae Durvasula, S.R. . . . .	346
704	Coastal Phytoplankton Dynamics Keizer, P.D. . . . .	349
705	Kelp and Seagrass Habitat Studies Mann, K.H. . . . .	352
707	Inshore Molluscan Habitat Studies Rowell, T.W. . . . .	355
708	Scallop Habitat Research Cranford, P.J. . . . .	359
709	Zooplankton Habitat Studies Harding, G.C. . . . .	363
710	Benthic Habitat Studies Rowell, T.W. . . . .	366
711	Benthic/Pelagic Exchanges Keizer, P.D. . . . .	368
712	Fish and Habitat Interactions Messieh, S.N. . . . .	371
713	Bioenergetics of Marine Mammals Brodie, P.F. . . . .	373
715	Size-Dependent, Bioenergetic Processes in Fish Habitat Kerr, S.R. . . . .	376
716	Habitat of Geographic Information Systems (GIS) Boudreau, P.R. . . . .	379
718	Evaluation of Estuarine and Continental Shelf Habitats Silvert, W.L. . . . .	381
719	Contaminant Fluxes in Marine Benthic Food Webs Hargrave, B.T. . . . .	384
720	Organochlorines in Arctic Ocean Marine Food Webs Hargrave, B. . . . .	387
722	Instrumentation Support Reimer, D.P. . . . .	390
723	Ballast Waters as a Source of Algal Blooms Durvasula, S.R. . . . .	392

977

Effect of Fishing Activity on Fish Habitat  
Vass, W.P. . . . .

394



PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division:

Project No.: 5900-0000

Section:

Project Title: Regional Director, Science Sector

Project Leader: MacPhee, S.B.

Other Researchers: Guilderson, J. ; Henderson, J.

Work Activity: W.A.1.1.5

Key Words: administration

1. Project Description:

To provide the scientific information necessary for the sustainable development of Scotia-Fundy Fisheries and Canada's Oceans; to ensure the availability of scientific information of the highest possible standard to internal and external clients for use in developing policies, regulations, legislation, and plans pertaining to the Region's aquatic activities such as fishing, industrial development projects, and aquaculture; to acquire and communicate scientific information on the impact of deleterious substances on aquatic ecosystems and habitats, on climate processes and how they influence marine resources, and on environmental parameters relevant to marine activities such as marine engineering and transportation; to chart Canadian Atlantic and Arctic waters to facilitate safe navigation, fishing and aquatic development activities; to develop and refine methods and technology necessary for the Region's scientific role, and transfer relevant technology to Canadian industry.

Note that the official Work Activity structure places this project within W.A. 1.1 (Biological Sciences) under the administrative W.A. 1.1.5. Resources in this project, although often reported as Biological Sciences resources in higher level (e.g. National) roll-ups, refer to the Science Sector as a whole.

2. Long-Term Objectives:

Continue to administer Science Sector activities according to Departmental priorities and the scientific requirements associated with the Departmental mandate. Continue to improve the advice provided to resource and habitat managers and industry by expanding the knowledge base on renewable resources in the aquatic environment.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Achievements are outlined in the Scotia-Fundy Region Year-End Review prepared by the Comptroller's Branch.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

Goals for 1992 are given in the current Accountability Accord for the Science Sector, and in the detailed project forms given in PREP documents prepared by the three Science Branches.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division:

Project No.: 5910-0000

Section:

Project Title: Director, Biological Sciences Branch

Project Leader: Sinclair, M.

Other Researchers: Lavoie, R.E. ; Guilcher, D. ; Harrie, K.

Work Activity: W.A.1.1.5

Key Words: direction; administration

1. Project Description:

Provision of scientific and administrative direction for the Biological Sciences Branch, Scotia-Fundy Region.

2. Long-Term Objectives:

To direct the activities of the Biological Sciences Branch according to Departmental priorities and the scientific requirements associated with the Departmental mandate. Continue to improve the advice provided to resource and habitat managers and industry by expanding the knowledge base on renewable resources in the aquatic environment.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Achievements are outlined in the Scotia-Fundy Region Year-End Review prepared by the Comptroller's Branch, and provided in detail within the projects given in the Branch PREP document.

4. Additional Accomplishments:

1. Co-chaired (with a provincial counterpart) the Nova Scotia Aquaculture Coordinating Committee. (Lavoie)
2. Prepared and delivered an invited paper to the seminar on the development of oyster culture in Malaysia. (Lavoie)
3. Led a mission in Sao Tome y Principe (West Central Africa) and provided a blue print to the establishment of a fisheries research capability for the country. (Lavoie)

5. Goals/Expected Outputs for 1992:

Goals for 1992 are given in the current Accountability Accord for the Science Sector, and in detail within the projects given in the Branch PREP document.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

R. Lavoie is a member of the Aquaculture Committee of APICS (Atlantic Provinces Inter-university Council on the Sciences).

St. Mary's University Fisheries Seminar Series (Sinclair)

University of Rhode Island Seminar (Sinclair)

iii. Communications -

iv. Contracts Administered -

G. Maillet (\$2.7K). Estimate abundance and distribution of herring larvae and their prey off Southwest Nova Scotia.

N. Carson (\$4K). Organizing, cataloguing and analyzing data from data bases and bibliographic sources for information relevant to a review of factors influencing the structure of marine ecosystems.

M.J. Dadswell (\$4K). Survey of sea scallop (Placopecten magellanicus) spat settlement on the Atlantic Coast of Nova Scotia and Annapolis Basin, Bay of Fundy.

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Lavoie, R.E. 1991. Infrastructure for oyster culture. In Report on the seminar on the development of oyster culture in Malaysia, Department of Fisheries, Malaysia, Kuala Lumpur, pp. 93-114.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Assessment &amp; Liaison

Project No.: 5901-0000 to 5907-0000

Section: Marine Assessment &amp; Liaison (5901), Scientific Computing (5902-05), CAFSAC (5906) and SCOR (5907)

Project Title: Marine Assessment &amp; Liaison

Project Leader: Nicholls, H.B.

Other Researchers: Koeller, P. ; Porteous, D. ; Seibert, G. ; Maguire, J.-J.

Work Activity: W.A.1.1.5

Key Words: administration ; computing ; CAFSAC ; habitat

1. Project Description:

This Division, reporting directly to the Regional Director of Science, provides a wide variety of services and functions for the Science Sector and its clients. It provides administrative support by coordinating Science Work Planning, Atlantic Science Vessel Scheduling, reporting of Sector activities, and Science communications with the public (e.g. Weekly Scientific Briefing newsletter). The Division provides and coordinates Science Sector advice required by DFO Habitat Managers, including major reviews under EARP. It also provides scientific computing services to regional scientists in the form of data communications and mainframe support. The Division provides the secretariat for the Canadian National Committee for SCOR/ECOR. The CAFSAC Secretariat, although an Atlantic-wide function, is situated in Scotia-Fundy and is placed under the Regional Science Director, and within this project, for administrative convenience.

Note that the official Work Activity structure places this project within W.A. 1.1 (Biological Sciences) under the administrative W.A. 1.1.5. Resources in this project, although often reported as Biological Sciences resources in higher level roll-ups (e.g. National), refer to the Science Sector as a whole.

2. Long-Term Objectives:

Continue to administer Science Sector activities according to Departmental priorities and the scientific requirements associated with the Departmental mandate. Continue to improve the advice provided to resource and habitat managers and industry by expanding the knowledge base on renewable resources in the aquatic environment.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Achievements are outlined in the Scotia-Fundy Region Year-End Review prepared by the Comptroller's Branch.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

Goals for 1992 are given in the current Accountability Accord for the Science Sector, and in the detailed project forms given in PREP documents prepared by the three Science Branches.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Services

Project No.: 5518-0000 to 5522

Section: EE Prince (5518), Alfred Needler (5519), Lady Hammond (5520), Sigma-T (5521), Navicula (5522)

Project Title: Biological Sciences Ships

Project Leader: Wheelhouse, J.

Other Researchers:

Work Activity: W.A.1.1.5

Key Words: ships; vessels; administration

1. Project Description:

Science ships - EE Prince, Alfred Needler, Lady Hammond (charter), Sigma-T, Navicula. Although these vessels are often used by DFO Regions other than Scotia-Fundy, and sometimes by Work Activities other than W.A. 1.1, and by other government departments and by universities, they are placed under this W.A. (1.1.5) for accounting convenience. Note that the vessels are administered and operated by the Management Services Sector.

The substantial resources in this project, although often reported as Biological Sciences, Scotia-Fundy resources in higher level roll-ups (e.g. National), also refer to vessel support provided to other DFO Atlantic Regions, and to other government agencies and universities.

2. Long-Term Objectives:

Continue to provide research platforms required for the variety of marine research conducted on the Atlantic Coast.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Achievements are outlined in the Scotia-Fundy Region Year-End Review prepared by the Comptroller's Branch, and by the MISAR ship activities reporting system.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

Goals for each vessel are outlined in the 1992/93 Vessel Work Plans prepared by Marine Services Division, and in the official Atlantic Science Vessel schedule prepared by the Marine Assessment & Liaison Division.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:



PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 000

Section: Administration

Project Title: Division Administration

Project Leader: O'Boyle, R.

Other Researchers: Gavaris, S.; Stephenson, R.; Bowen, D.; Frank, K.; Halliday, R.

Work Activity: W.A.1.1.1

Key Words: administration

1. Project Description:

Administration of the Marine Fish Division.

2. Long-Term Objectives:

Administer the Marine Fish Division efficiently and to provide scientific leadership in interpreting and accomplishing the mandate of the Division.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide administrative support for BIO component including continued upgrading of requisition processing, time management initiatives and monitoring of overtime usage.

All administrative functions were conducted effectively. Focus was placed on the use of PY resources, in preparation for salary management. In particular, a report on the distribution of PYS by project was compiled. This was useful in the mandate sharing issue (see Goal #2).

2. Provide administrative support for STABS component including monitoring of progress to meet objectives of the accord.

Early in the year, Dr. Cook announced his intention to step down as STABS Station Director. The Branch Director and he saw this as an opportunity to reconsider the relationship among the two MFD components (BIO and STABS) and the other scientific groups at the Biological Station. The intent was to provide the new Station Director with the authority to implement MFD programs. The MFD Division Chief would provide functional leadership for the scientific programs, but not be involved in the day-to-day direction of these at the station. Under this working relationship it was evident that the two MFD components should become as autonomous as possible, in relation to support (eg. ageing and surveys) functions. Division-wide discussions were held to consider a new sharing of mandates between BIO and STABS. This resulted in 4X cod and pollock assessments being transferred to STABS and 4VsW cod ageing and surveys, 4TVWX haddock ageing and silver hake ageing moving to BIO. Initial steps were taken in the implementation of this new working relationship.

3. Foster communication between BIO and STABS through coordination of activities at both sites (O'Boyle), section head meetings and scientific consultations, both through the year and as part of PREP.

Regular section head meetings were held up until November at which time the discussions on the mandate sharing took precedence. At BIO, PREP was conducted as primarily a paper exercise, a departure from previous years. The St. Andrews component had a meeting for its staff to discuss scientific programs. At BIO, it was considered more efficient to delay discussion until the planned long-term planning meetings in February 1992.

4. Provide computer maintenance support for BIO PCs as well as training in wordprocessing for administrative personnel. (Branton)

Computer maintenance support was effectively administered.

5. Provide computer maintenance support for STABS PCs as well as training in wordprocessing for J. Hurley. (Gale)

Computer maintenance support was effectively administered.

6. Support of DFO Science Subvention program, including participation in National Review. This will be the third and final year of this involvement. (Neilson)

Coordinated the review of some 70 Science Subvention proposals with the Region and served on the National Review Committee.

7. Continue to serve as Associate Editor, Canadian Journal of Fisheries and Aquatic Sciences. (Neilson)

Duties of Associate Editor, CJFAS, were continued.

8. Process tag returns from historical tag experiments. (Nelson)

Roughly two-dozen tag returns were processed.

4. Additional Accomplishments:

1. Conducted MFD/FHMB discussions to investigate how better to meet the growing needs of management. (O'Boyle)
2. Conducted MFD/Economics/Statistics discussion to improve the flow and use of catch/effort statistics among the users. (O'Boyle)
3. Established Regional IOP Working Group to provide a forum for dialogue between MFD and FHMB on the goals and implementation of the IOP. See also project 1130. (O'Boyle)
4. Facilitated a number of work re-assignments under SFAP to improve job satisfaction for those involved. (O'Boyle)
5. Spent considerable time meeting the reporting requirements of AFAP. (O'Boyle)

5. Goals/Expected Outputs for 1992:

1. Provide full range of administrative and secretarial support for the BIO component. Particular attention will be given to improved requisition processing and budget reporting, the monitoring of leave and overtime and establishment of a system to control salary dollar utilization. (O'Boyle, with Stobo, Myra and McMillan)
2. Develop and implement a plan for establishment of new activities at BIO and STABS, as part of the new mandate sharing arrangement. Dependent upon budgets, this plan should be completed by 31 March 1993. (O'Boyle)
3. Develop new working relationship with STABS staff which focuses on program rather than administrative issues. As part of this, develop working relationship with new Station Director. As well, conduct Division-wide long-term planning exercise. (O'Boyle)
4. Process tag returns from historical tag experiments. (Nelson)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

Presented paper entitled "Fisheries Management Systems: A Study in Uncertainty" at CAFSAC Risk Workshop. (O'Boyle)

7. Publications:

i. Primary -

Cohen, E.B., D.G. Mountain, and R. O'Boyle. 1991. Local-scale versus large-scale factors affecting recruitment. Can. J. Fish. Aquat. Sci. 48: 1003-1006.

O'Boyle, R.N., A.F. Sinclair, and P.C.F. Hurley. 1991. A bioeconomic model of an age-structured groundfish resource exploited by a multi-gear fishing fleet. ICES Mar. Sci. Symp. 193: 264-274.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Sinclair, A., D. Gascon, R. O'Boyle, D. Rivard, and S. Gavaris. 1991. Consistency of some Northwest Atlantic groundfish stock assessments. NAFO Sci. Coun. Studies. 16: 59-77.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The administration and organization of Marine Fish Division underwent significant changes which will influence the delivery of the mandate for a number of years to come. With a sharing of the administrative load between the Division Chief and the new Station Director, there will be more time to discuss programs. As well, the changing in mandate at both sites should lead to long-term benefits in program implementation.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1001

Section: Pelagic Fisheries

Project Title: Herring Assessments and Associated Research (Subarea 4)

Project Leader: Stephenson, R.

Other Researchers: Sochasky, J.; Power, M.; Gordon, J. (until June 1991); Dougherty, W.; Fife, J. (from Sept 1991); Melvin, G.

Work Activity: W.A.1.1.1.6

Key Words: NAFO 4WX; NAFO 4Vn; Bay of Fundy; pelagic fish; herring; assessments; assessment research; resource surveys; ichthyoplankton; commercial sampling

1. Project Description:

Assessments of herring stocks are conducted, as required, to provide advice for management of fisheries in 4WX (Bay of Fundy and Scotian Shelf) and 4Vn (Sydney Bight). Research into aspects of herring biology at the larval, juvenile and adult stage is conducted in support of assessments. Research into assessment methodology is undertaken to improve the accuracy and precision of management advice. Section personnel participate in industry and management meetings, as required, to explain or elaborate on assessments and research findings, and to advise on management strategies.

Involves part of the Scotia-Fundy data collection network which obtains biological information from sectors of the commercial fishing industry, particularly herring (see also Project 112 - Groundfish). Data are used as input to fish stock resource assessments. The program conducts research aimed at improved sampling and collects data for various research programs.

2. Long-Term Objectives:

Provide biological basis for advice on management of 4WX and 4Vn herring stocks; improve upon the analytical basis for advice, and provide, through research programs, a better biological base for assessment and advice. Sample commercial herring landings as an integral part of the stock assessment process, and to improve sampling procedures and efficiency through research into sampling methods.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Conduct and improve upon the 4WX herring assessment including: (a) further improvement in analytical procedures; (b) attempt summer acoustic survey of spawning aggregations; (c) evaluation of impact of recent misreporting. Provide advice to DFO Working Group, Scotia-Fundy Herring Advisory Committee and the Herring Fishing Industry. (Stephenson)

The 4WX herring assessment was prepared and presented at CAFSAC (CAFSAC Res. Docs. 91/58, 91/54). Improvement was made through refinement of the bottom trawl abundance index, but the analytical assessment was compromised by misreporting. Backcalculation from production records (roe production) demonstrated that landings for the 1990 fishery must have been substantially higher than recorded, and that there had been a variable degree of misreporting in recent years. Steps were taken to correct the historical record through backcalculation from production records and industry (fishermen/processor) interviews.

Acoustic surveys of spawning aggregations were attempted in Scots Bay (E.E. Prince; July 25-Aug. 2/91) and on German Bank (E.E. Prince; Sept. 3-13/91). These confirmed the problems of locating and surveying tightly aggregated, rapidly moving summer aggregations of herring, but indicated some potential if undertaken in close association with the fishing fleet (see Project 1230).

Advice was provided at meetings of the DFO Herring Working Group, the Scotia-Fundy Herring Advisory Committee and at a variety of meetings with members of the herring fishing industry (including AHFM Co-op. AGM).

2. Conduct port sampling for herring landed on the New Brunswick side of the Bay of Fundy. Monitor and compile herring samples from NSP and IOP programs. Carry out laboratory examination, ageing data coding and summaries of herring from all commercial catch samples in support of 4WX and other herring assessments. Continue to improve sampling strategy and efficiency. Complete pelagic sample data base and edit procedures. (Stephenson, Gale)

Port sampling objectives for the New Brunswick landings were met. Section personnel worked closely with OSS monitors and improved communication within the NSP program in an attempt to improve sampling. Laboratory examination, ageing and data processing for the 1990 fishery was completed and formed the basis for assessment documentation (CAFSAC Res. Doc. 91/58). Pelagic sample data bases and edit procedures were defined and created.

3. Conduct autumn Bay of Fundy larval herring survey to calculate a larval abundance index for 4WX

herring (late Oct./early Nov., E.E. Prince). Undertake further analysis of larval herring dynamics in relation to its impact on the larval abundance index. Develop larval herring data base and edit system. (Stephenson, Gale)

The autumn Bay of Fundy larval herring survey was completed successfully (E.E. Prince cruise 422; Oct. 28-Nov. 15/91). All traditional index stations were sampled in spite of poor weather.

Analysis of larval herring dynamics focused on collaboration with members of MFD and PCSB in the modelling of larvae with respect to hydrography of the Bay of Fundy (\*LaHope Project\*; see also Project 1250).

4. Continue studies relating to stock structure and management units for herring in the Bay of Fundy and Gulf of Maine, including: (a) further analysis of stock identification; (b) define issues concerning transboundary nature of adult herring on Georges Bank and juveniles in coastal waters. Participate in Can./U.S. meeting, Woods Hole (July). (Stephenson)

Progress on stock structure studies was hampered by the early retirement of D. J. Gordon. The Canada/U.S. meeting was not held, but participation in the U.S. SARC resulted in plans for a workshop which will include discussion of the transboundary herring issue.

5. Participate in the ICES Herring Assessment Working Group (south of 62°N) (April 2-12) and continue comparison of assessment methods for east and west Atlantic herring stocks. (Stephenson).

Stephenson participated in the ICES Herring Assessment Working Group (south of 62°N). A resulting paper comparing tuning methods in eastern and western Atlantic herring assessments was contributed to the ICES Statutory meeting (Sept. 1991).

6. Continue to define and monitor the interaction between salmon aquaculture and traditional fisheries, particularly the weir fishery. (Stephenson)

Stephenson contributed to a number of meetings of the Southwest N.B. Aquaculture Working Group, but a planned survey was dropped because of other priorities. An article summarizing the issue was published in National Fisherman.

#### 4. Additional Accomplishments:

Stephenson and Melvin participated in U.S. SARC #13 review of Gulf of Maine herring assessment.

Stephenson participated in PSARC review of Pacific herring assessments.

Summer student volunteer (K. Judge, St. John's Kilmarnoch school) drafted plans for a herring display for the HMSC/DFO aquarium/museum.

#### 5. Goals/Expected Outputs for 1992:

1. Conduct and improve upon the 4WX herring assessment, including: a) revision of catch-at-age to account for misreporting and b) further improvements in analytical procedures. Provide advice to DFO Herring Working Group, SFHAC and the herring fishing industry. Continue collaboration on evaluation of the 10-year purse seine plan. (Stephenson)
2. Conduct port sampling for herring landed on the New Brunswick side of the Bay of Fundy. Monitor and compile herring samples from NSP and IOP programs. Carry out laboratory examination, ageing, data coding and summaries of herring from all commercial catch samples in support of 4WX and other herring assessments. Continue to improve sampling strategy and efficiency. (Stephenson)
3. Conduct autumn Bay of Fundy larval herring survey to calculate a larval abundance index for 4WX herring (late Oct./early Nov., E.E. Prince). Undertake further analysis of larval herring dynamics in relation to its impact on the larval abundance index, including participation in LaHope Project. Develop larval herring data base and edit system. (Stephenson, Gale)
4. Improve abundance indices, including revisions to acoustics and trawl indices and evaluation of potential alternatives based on purse seine logbook set rates and perhaps index weirs. (Stephenson)
5. Participate in ICES Herring Assessment Working Group (S of 62°N). Continue comparison of east and west Atlantic herring assessments, including evaluation of biological basis for reference points in herring. (Stephenson)
6. Write up stock ID results on parasites, morphometrics and meristics. (Stephenson)
7. Participate in proposed Gulf of Maine Herring Workshop, particularly with respect to developing consensus on transboundary juveniles (4X/5Y). (Stephenson)

#### 6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -

I. Kornfield (Univ. of Maine, Orono), genetic aspects of stock identification in herring.

P. Smith, K. Tee (PCS/BIO) and F. Page (MFD), collaborative study and model of larval herring dynamics.

D. Aldous (FHMB/DFO) and D. Lane (Univ. of Ottawa), aspects of the management of 4WX herring.

R. Bradford (Dalhousie Univ., and DFO, Quebec Region), aspects of herring spawning strategies.

ii. University Liaison -

Honorary Research Association, Dept. of Oceanography, Dalhousie Univ. (Stephenson). Seminars and lectures given to fisheries/marine ecology. Courses at Huntsman Marine Science Centre.

iii. Communications -

Larval herring, modelling study was presented in three conference presentations (CMOS and ASLO) and was subject of CBC radio interview. Herring assessment formed basis of several newspaper reports. Article on traditional fisheries/aquaculture, interaction was written for National Fisherman. (Stephenson)

iv. Contracts Administered -

Enumeration and curation of fish larvae and zooplankton. Atl. Reference Centre, HMSC - \$32k.

v. Other -

DFO representative on Huntsman Marine Science Centre Users Committee. (Stephenson)

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Buerkle, U., and R.L. Stephenson. 1991. Herring school dynamics and its impact on acoustic abundance estimates, p. 185-207. In: V. Wespestad, J. Collie, and E. Collie (ed.) Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990 (9th Lowell Wakefield Fisheries Symp.). University of Alaska, Fairbanks.

Page, F.H., K-T Tee, P.C. Smith, and R.L. Stephenson. 1991. \*A 3-D Lagrangian particle tracking model for the southwest Nova Scotia region: description and application to the dispersal of herring larvae. ASLO, Halifax.

Page, F.H., R.L. Stephenson, K-T Tee, and P.C. Smith. 1990. \*Investigating the influence of the barotropic tidal circulation on herring larval dispersal in the southwest Nova Scotia region using a 3-D Lagrangian particle tracking model.\* 25th Annual Canadian Meteorological and Oceanography Society Congress, Winnipeg.

Power, M.J., and R.L. Stephenson. 1991. Logbook analysis for the 1990 4WX herring purse seine fishery. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 91/54: 27 p.

Stephenson, R.L. 1991. Stock discreteness of Atlantic herring: a review of arguments for and against, p. 659-666. In: V. Wespestad, J. Collie, and E. Collie (ed.) Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990 (oth Lowell Wakefield Fisheries Symp.). University of Alaska, Fairbanks.

Stephenson, R.L., and D.J. Gordon. 1991. Comparison of meristic and morphometric characters among spawning aggregations of northwest Atlantic herring, Clupea harengus L., p. 279-297. In V. Wespestad, J. Collie, and E. Collie (ed.) Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990 (oth Lowell Wakefield Fisheries Symp.). University of Alaska, Fairbanks.

Stephenson, R.L., and M.J. Power. 1991. Diel vertical movements of Atlantic herring in relation to food availability and abundance, p. 73-83. In W. Wespestad, J. Collie, and E. Collie (ed.) Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990 (oth Lowell Wakefield Fisheries Symp.). University of Alaska, Fairbanks.

Stephenson, R.L., and J.B. Sochasky. 1991. Epibenthic occurrence of Atlantic herring larvae during a study of vertical migration: implications for traditional sampling, p. 85-101. In V. Wespestad, J., J. Collie, and E. Collie (ed.) Proceedings of the International Herring Symposium, Anchorage, Alaska, October 23-25, 1990 (oth Lowell Wakefield Fisheries Symp.). University of Alaska, Fairbanks.

Stephenson, R.L., M. J. Power, U. Buerkle, W.H. Dougherty, D.J. Gordon, J.B. Sochasky and G.D. Melvin. 1991. Assessment of the 1990 4WX herring fishery. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 91/58: 49 p.

Stephenson, R.L. 1991. Comparisons of tuning methods used in herring stock assessments in the northeast and northwest Atlantic. Int. Comm. Explor. Sea C.M. 1991/H:39 (Sess U): 8 p.

Stephenson, R.L., P.C. Smith, K-T Tee, and F.H. Page. 1991. \*Persistence of herring larvae off southwest Nova Scotia: a result of physical/biological interactions?\* ASLO, Halifax.

## iv. Popular and Miscellaneous -

Stephenson, R.L. 1991. Competition in the Bay of Fundy. National Fisherman 72:1: 24-25.

8. Review and Evaluation:

The recent problems in catch misreporting have severely compromised the 4WX herring assessment and once again point to the importance of having reliable independent estimates of abundance. Currently the larval survey is the main index with increasing use being made of the acoustic survey. Experiments undertaken during the review period show the difficulty of summer surveys, and suggest refinements to the winter survey may be more fruitful. Generally the project is proceeding well.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1005

Section: Pelagic Fisheries

Project Title: Herring Assessment and Associated Research (Subarea 5)

Project Leader: Melvin, G.

Other Researchers:

Work Activity: W.A.1.1.1.6

Key Words: NAFO 5Z; Georges Bank; pelagic fish; herring; assessment research; resource surveys; ichthyoplankton

1. Project Description:

Research into aspects of herring biology is conducted in support of assessment of stock status as required for management. Project personnel participate in industry and management meetings, as required, to explain or elaborate on assessments and research findings, and to advise on management strategies.

2. Long-Term Objectives:

Provide advice on management of 5Z herring stocks; improve upon the analytical basis for advice; and provide through research programs, a better biological base for assessment and advice.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare review report on the recovery of Georges Bank herring population. Analyze and summarize the 1988/89 Canada and U.S. larval cruise data to advise CAFSAC of the current status of Georges Bank herring. Participate in CAFSAC to become familiar with quantitative assessment approaches and computational methodologies. (Melvin)

A detailed summary of recent Canada and U.S. data was presented to CAFSAC in May 1991. Georges Bank herring continue to show strong signs of recovery with respect to biological indicators. However, the geographical distribution is far more restricted than it was in the late 60s and early 70s when the stock peaked. The results of this review are presented in a CAFSAC Research Document.

2. Conduct fall larval fish and adult age distribution survey on Georges Bank to investigate herring distribution (Oct./Nov.). Compute larval abundance index for 5Ze herring to assist in future fishery assessment and management. (Melvin)

The 1991 fall larval/adult herring survey on Georges Bank was expanded from the traditional area to incorporate the northeast tip as recommended by CAFSAC. Although the area of coverage was expanded, the number of stations occupied was reduced due to poor weather. Preliminary results indicate that the majority of spawning had not occurred at the time of the survey. Larval indices when computed for 1991 should reflect this delay.

Indices of abundance (i.e. # larvae/10 m<sup>2</sup> and # of herring per standard tow) were calculated from Canadian and U.S. survey data. Both indicated a dramatic increase over the lean period of the early 80s. Details are presented in CAFSAC Res. Doc. 91/55.

3. Initiate long-term research program for assessment and management of Georges Bank herring. Investigate the relationship of Georges Bank herring (i.e. fecundity, growth and age-specific mortality) and stock recovery. Examine the possibility of utilizing changes in these characteristics as an indicator of an expanding or contracting stock. Review historical and recent data bases for information which could account for the convergence of spawning periods of Georges Bank and Nantucket Shoals during the declining years - the 70's. Undertake to estimate spawning time from larval cruise data in relation to observed physical changes which have occurred on the bank (e.g. temperature/salinity). (Melvin)

Long-term research programs to investigate the relationship of biological parameters and stock recovery were initiated during 1991. Data concerning growth and age-specific factors were reviewed and documented. Gonad samples from adult fish collected in 1990 and 1991 are currently being prepared for fecundity studies. Only a few samples were collected in 1990 due to the timing of spawning. Preliminary work on utilizing mean length at age of herring as an indicator of stock status was undertaken with encouraging signs. More years of data are, however, required before any firm conclusions can be drawn. Changes in spawning period were also evaluated by estimating the approximate date of hatching from larval length. This information was not compared with physical changes which have occurred on the Bank. Further work in this area is required.

4. Review existing acoustic survey methodologies and determine their appropriateness for Georges Bank herring assessment. Reconnoitre commercial vessels to observe approaches and equipment

employed in searching for herring. Assess the applicability of commercial gear for assessment of herring on Georges Bank. (Melvin)

The futility of using an acoustic survey to monitor and assess Georges Bank herring stock, which covers a large area, was confirmed by the 1990 survey. Simulation of traditional acoustic survey designs indicated that the probability of locating a 1-km school of herring in a 15-km grid was extremely low. Consequently, alternative methods must be examined.

During the summer of 1991, several excursions on commercial herring vessels were undertaken to observe their approach to finding herring with sonar.

At the 1991 fall SFHAC meeting, a working group, which includes industry and fishermen, was established to evaluate the possibility of conducting an experimental scientific survey that utilizes commercial vessels. A proposal for this survey will be presented to the spring 1992 SFHAC for implementation in the fall of 1992. A component of this survey will be to evaluate the usefulness of sonar gear in locating and assessing herring stocks on Georges Bank.

5. Meet with individuals representing the herring fishery and industry for familiarization with biological concerns and regulatory issues, as well as their feeling about future uses of Georges Bank herring - assuming it recovers to commercially exploitable levels. (Melvin)

During 1991, two SFHAC meetings were attended as well as several fishing excursions were made with the commercial fleet to observe the process and to discuss with members of industry their general feelings about the fishery.

6. Attend the Gulf of Maine Scientific Workshop (Jan. 8-10, 1991) and Can./U.S. meetings (July) in Woods Hole, Mass. for the purpose of introduction to researchers working on Georges Bank. Attend International conference and/or ICES to get an overview of herring research in other parts of the world (e.g. Europe). (Melvin)

The Gulf of Maine Workshop in Woods Hole was attended and provided valuable information and scientific contacts in the U.S. The Canada/U.S. meetings were not held in 1991 and no international conferences were attended. Participation in the 1991 SARC to review the U.S. herring assessment in December of 1991.

7. Complete partly completed scientific papers for publication. (Melvin)

Three scientific publications were completed in 1991 (see publications).

#### 4. Additional Accomplishments:

1. Participated in Feb. CAFSAC.
2. Participated in 4X herring assessment (Res. Doc. 91/58).

#### 5. Goals/Expected Outputs for 1992:

1. Prepare an annual review on the recovery of Georges Bank herring stock. This will include discussion and the establishment of a biological bases (threshold) for the opening of a commercial fishery. Participate in both pelagic CAFSAC meetings as well as a proposed Can./U.S. workshop on the Gulf of Maine herring in 1992. (Melvin)
2. To conduct and improve the 1992 fall larval/adult herring survey on Georges Bank. This will include the expansion of geographical coverage to the northeastern tip as recommended by CAFSAC as well as additional bottom trawl sets using a random stratified design. Backcalculations from larval densities will be undertaken to estimate SSB during the years of Canadian surveys. (Melvin)
3. To initiate a scientific survey involving commercial vessels which will investigate: i) the distribution of herring on the northeastern tip of Georges Bank during the spawning, ii) the seasonal movement of herring using tags and iii) the usefulness of sonar in a quantitative survey. The information collected during this survey will be reviewed in conjunction with our current assessment surveys to establish a strategy for the future. (Melvin)
4. To continue long-term research programs initiated in 1991 on density-dependent factors such as fecundity and growth which may act as indicators of an expanding or contracting stock and assist in future assessments of this stock. (Melvin)
5. To begin the groundwork for establishment of harvest strategies for this transboundary resources (Y/R vs SSB/R, etc.) in collaboration with R. Stephenson. (Melvin)
6. To continue involvement with the herring fishery and industry for determining biological concerns, regulatory issues and their possible future needs/anticipations for Georges Bank herring. This will involve several trips aboard commercial vessels as well as attendance at two SFHAC meetings. (Melvin)
7. Participate in future SARC, ICES and Canada/U.S. working groups to become familiar with U.S. assessment processes, get an overview of herring research in other parts of the world and to remain abreast of the information/research on Georges Bank herring. (Melvin)

#### 6. Background:

Highlights:

## Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

Processing, identification and enumeration of ichthyoplankton samples from the Bay of Fundy and Georges Bank herring surveys.

- v. Other -

7. Publications:

- i. Primary -

Melvin, G.D., M.J. Dadswell, and J.A. McKenzie. 1992. The usefulness of meristic and morphometric characters in discriminating populations of American shad, Alosa sapidissima, inhabiting a marine environment. Can. J. Fish. Aquat. Sci. 49: 266-280.

- ii. Interpretive Scientific -

- iii. Scientific and Technical -

Melvin, G.D. 1991. Striped Bass of Eastern Canada - A review of striped bass, Morone saxatilis, population biology of eastern Canada. Ed. R. Peterson. Proceedings of a workshop on the biology and culture of striped bass (Morone saxatilis). Can. J. Fish. Aquat. Sci. Tech. Rep. 1832: 1-11.

Melvin, G.D., J.B. Sochasky, M.J. Power, J.D. Gordon, and W.H. Dougherty. 1991. An update on Georges Bank (5Z) herring. Can. Atl. Fish. Sci. Adv. Comm., Res. Doc. 91/55: 39 p.

Stephenson, R.L., M.J. Power, U. Buerkle, W.H. Dougherty, D.J. Gordon, J.B. Sochasky and G.D. Melvin. 1991. Assessment of the 1990 4WX herring fishery. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 91/58: 49 p.

- iv. Popular and Miscellaneous -

8. Review and Evaluation:

The groundwork has been laid for the long-term success and stability of this research program. Existing data sets were tapped to provide indices of abundance and have indicated stock resurgence. This has led to further refinement of these indices and consideration of management strategies. All the essential elements for the biological basis for management have been considered and are being pursued.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1011

Section: Southern Shelf

Project Title: 4TVW Haddock Assessment and Associated Research

Project Leader: Zwanenburg, K.

Other Researchers:

Work Activity: W.A.1.1.1.2

Key Words: groundfish; haddock biology; assessments; assessment-related research; NAFO  
4TVW1. Project Description:

Conduct annual assessments of haddock in NAFO Divisions 4TVW, as required for management of the fishery by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into haddock biology and assessment methodology is conducted to improve the accuracy and precision of management advice. Assessment personnel participate in industry-management meetings as required to explain or elaborate on assessments and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of 4TVW haddock stocks, and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Produce an assessment of the 4TVW haddock stock incorporating the recommendations made by the CAFSAC Groundfish Subcommittee at its May 1990 meeting. (Zwanenburg)

An assessment of this resource was completed and presented at the CAFSAC Groundfish Subcommittee meeting in Dartmouth in May 1991. Retrospective patterns in F continue to be observed, precluding the acceptance of SPA based analyses. Analyses of RV data indicate the influx of a large cohort hatched in 1988.

2. Complete the analysis of haddock tag return data and publish results. (Zwanenburg)

Due to time constraints these analyses were not completed. Tags continue to be returned and their analyses will be continued.

3. Initiate analysis of haddock mitochondrial DNA from Northeast Atlantic fish. (Zwanenburg)

Samples of haddock from the Northeast Atlantic were analyzed and found to contain degraded mtDNA. These results indicate that more sophisticated analytical techniques will be required to generate data for comparison to the Northwest Atlantic results. Project will not be continued next year. Paper for Northwest Atlantic was completed and has been submitted to CJFAS as Zwanenburg, K.C.T., P. Bentzen, and J.M. Wright, 1992, Mitochondrial DNA Differentiation in Western North Atlantic Populations of Haddock (*Melanogrammus aeglefinus*).

4. Continue to act as an MFD representative on the Scotia-Fundy Groundfish Advisory Committee. (Zwanenburg)

Attended Scotia-Fundy Groundfish Advisory Committee meetings and provided advice on question of a biological nature arising from issues discussed.

4. Additional Accomplishments:

1. Prepared and presented a half-day seminar on fisheries science, specifically on the analysis of recruitment processes and cohort dynamics. The seminar was presented to the International Oceans Institute's course on Management and Conservation of Marine Resources within the exclusive Economic Zone. (Zwanenburg)
2. Chaired an inter-regional working group of the CAFSAC Groundfish Subcommittee tasked with establishing a protocol for the assessment of secondary resources. Two meetings were held, a consensus report written and this presented to the steering committee of CAFSAC. The recommendations arising from this report have now been adopted by CAFSAC. (Zwanenburg)
3. Prepared and presented a paper entitled 'What to do when SPA fails' at the CAFSAC sponsored International Workshop on Risk Analysis held in Halifax, November 19-22, 1991. (Zwanenburg, Frank)

4. Was appointed core member of the CAFSAC Groundfish Subcommittee for MFD/BIO.

5. Goals/Expected Outputs for 1992:

1. Produce an assessment of 4TVW haddock incorporating the recommendations made by the CAFSAC Groundfish Subcommittee at its May 1991 meeting. The process through which this assessment will be prepared is outlined in Appendix attached. (Zwanenburg)
2. Prepare a manuscript for publication, documenting the results of the 4VW haddock tagging experiment. (Zwanenburg)
3. Continue to participate on the Scotia-Fundy Groundfish Advisory Committee. (Zwanenburg)
4. Hold meetings with industry representatives to discuss issues relevant to 4TVW haddock when required. (Zwanenburg)
5. Act as CAFSAC Groundfish Core Member for MFD/BIO component. (Zwanenburg)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Zwanenburg, K. 1990. Haddock on the Eastern Scotian Shelf 1990. CAFSAC Research Document 90/92.

Zwanenburg, K., and P. Comeau. 1991. Haddock on the Eastern Scotian Shelf 1991. CAFSAC Research Document 91/47.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The presence of the retrospective pattern in the 4TVW haddock assessment has distracted considerably from its utility. This resource is the focus of attention for many Nova Scotia fishermen. It is recommended that, as in other areas, formal input from fishermen be sought as input to the assessment process.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1012

Section: Southern Shelf

Project Title: 4X Haddock Assessments and Associated Research

Project Leader: Hurley, P.

Other Researchers: Frank, K.; McRuer, J.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; haddock; assessments; assessment-related research; NAFO 4X

1. Project Description:

Conduct annual assessments of haddock stocks in NAFO Division 4X, as required for management of the fishery by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into haddock biology and assessment methodology is conducted to improve the accuracy and precision of management advice. Assessment personnel participate in industry-management meetings as required to explain or elaborate assessments and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of 4X haddock stock, and improve the quality of advice as new information or methodologies become available through research. Explore non-traditional methods of estimating stock size, eg. density-dependent growth, stock area/abundance relationships, biological reference points.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Produce assessment for the 4X haddock stock and present for regional review and, if necessary, to the CAFSAC Groundfish Subcommittee and to FINS. CAFSAC research recommendations were a) define areas in NAFO Division 4X for consideration of year round closure to the fishery in order to conserve the haddock resource; b) the catch at age should be provided by gear sector and quarter to allow calculation of population biomass appropriate for comparison with survey catch rate data. (Hurley, Frank)

Objective achieved as planned. Assessment was presented to CAFSAC during May Groundfish Subcommittee meeting. Several new research recommendations were made by CAFSAC as a result of trends in distribution patterns and in size at age found during the analysis.

2. Conduct survey of inshore areas for juvenile haddock in NAFO Division 4X to develop an abundance index, determine the degree of persistence of haddock distributions by age group in areas where historical concentration (based on RV survey data) are high, and depending on outcome of haddock tagging data analysis, initiate juvenile tagging study. Ship time has been requested each month from May to September for 1 week aboard the J.L. Hart. (Hurley, Frank)

Objective achieved as planned. Overtime restrictions on ship's crew resulted in limited survey time and severely limited some of the scientific objectives. Breakdown of the vessel precluded scheduled work in September and October. Tagging was not attempted. Survey results are being analyzed.

3. Depending on availability of Biosonics equipment, explore possibility of combining acoustics survey with inshore juvenile survey detailed in 2) above. (McRuer, Hurley, Frank)

Biosonics gear was not available.

4. Continue analysis of historical tagging data base to determine the efficacy of establishing closed areas to protect the haddock resource in NAFO Division 4X. (Hurley, Frank, Stobo)

Preliminary results suggest limited within season movement of young haddock from tagging sites in St. Mary's Bay and on Browns Bank. Analysis continuing.

5. Continue analysis of haddock RV survey data in 4X to determine the influence of hydrographic and meteorological factors on abundance trends and catch rates incorporating hypotheses generated by discussions with fishermen. (Hurley)

Hydrographic and meteorological data for spring, summer and fall surveys in 4X have been obtained and analysis is continuing.

6. Continue analysis of juvenile haddock survey data collected in 1989 and 1990 with emphasis on a) regional distribution patterns, diet and growth (Frank, Hurley); and b) optical plankton counter and hydroacoustics data (McRuer, Frank, Hurley).

Preliminary results show inshore/offshore pattern in ration and fish size consistent with established differences in growth between two regions. OPC data has been edited and binned into time and size units and preliminary analysis started. Hydroacoustic data tapes have been read and show high levels of ship interference. Further processing is planned. Analysis continuing.

7. Prepare a manuscript for publication on the inter-comparison of three condition indices (otolith microstructure, biochemical, morphological) for juvenile cod. (Frank with Suthers)

Manuscript accepted for publication in Mar. Ecol. Prog. Series in 1992. Title: "Comparison of lipid, otolith and morphometric condition indices of pelagic juvenile cod (Gadus morhua) from the Canadian Atlantic". (Frank with Suthers and Fraser)

8. Continue supervision of Ph.D. student T. Marshall in Dept. of Oceanography, Dalhousie. (Frank)

Thesis supervision continuing on topic of variability in abundance, distribution and growth of haddock.

9. Serve as convener of the Special Session entitled "Fisheries oceanography: analysis of distribution and production patterns" for ASLO at the June 1991 meeting. Responsibility for inviting speakers and reviewing abstracts for the full day session. (Frank)

Objective achieved as planned. Plenary lecture was also given on Session theme.

10. Serve as core member to CAFSAC Surveys, Sampling and Statistics Subcommittee. (Hurley)

Objective achieved as planned. Attended spring meeting and participated in several teleconferences of subcommittee.

#### 4. Additional Accomplishments:

1. Participated in FINS presentations at Barrington Municipal High School (Frank), and at Eastern Canadian Fisheries Exposition in Yarmouth and Nova Scotia Fisheries Festival in Lunenburg, and with fisheries organizations in Newellton, Yarmouth and Grand Manan. (Hurley)
2. Participated in and presented 2 papers at 2 Northern Cod Science program sponsored workshops on Juvenile Studies and Biomass Spectrum during 20-22 March and 25-27 March respectively. (Frank)
3. Organized NSERC Site Visit to BIO by Evolution and Ecology Grant Selection Committee. (Frank)
4. Presented paper at MEES workshop on juvenile fish ecology. (Frank)
5. Co-authored paper presented at CAFSAC SSSS workshop on Risk Analysis and Biological Reference Points, titled "What to do when SPA fails?" (Frank with Zwanenburg)
6. Assisted in development of draft terms of reference for CAFSAC Fisheries Oceanography Subcommittee. (Frank)
7. Participated in 4X leg of July groundfish survey. (Hurley)
8. Attended several meetings of SFGAC and 4X+5 Groundfish Working Group. (Hurley)
9. Presented 2 lectures on stock assessment to Fish Biology course at Dalhousie. (Hurley)
10. Assisted in creation of Division Safety Training plan (Hurley); completed St. John's Ambulance first aid training at standard level (Frank); Marine Emergency Duties level A1 training (Hurley).
11. Provided guided tour of BIO facility to Bedford Cub Scouts. (Frank)

#### 5. Goals/Expected Outputs for 1992:

1. Produce assessment for the 4X haddock stock and present to CAFSAC Groundfish Subcommittee for review. Research recommendations were: a) the magnitude of misreporting that occurred during the 1980s, particularly 1985-88, should be determined and the catch at age corrected appropriately; b) the trend of increasing weights at age seen in both the research survey and the commercial catch in recent years should be investigated; c) analysis to identify areas that are critical to conservation and growth of the 4X haddock stock for closure to the fishery, should include analysis of the impact on the fisheries for 4X haddock and other species, both inside and outside the area; quantification of the rates of haddock movement through the area, through analysis of historical tagging and research survey data; definition of specific targets that will enable evaluation of the effectiveness of the closure, the duration required and the predicted effect of the haddock stock. (Hurley, Frank)
2. Plan and chair meetings of the newly created Fisheries Oceanography Subcommittee of CAFSAC. (Frank)
3. Conduct survey for juvenile haddock in inshore areas of NAFO Division 4X towards developing an abundance index, to determine the persistence of haddock distributions and the physical and biological factors producing these distributions. Vessel time has been requested for 3 weeks on the J.L. Hart to overlap with the July groundfish survey. (Hurley, Frank)
4. If acoustics equipment is available, explore possibility of combining acoustics survey with inshore survey detailed in 2) above. (Hurley with Page, Clark)
5. Continue analysis of historical tagging data base to determine the efficacy of establishing closed areas to protect the haddock resource in NAFO Division 4X. (Hurley, Frank, Stobo)

6. Continue analysis of haddock RV survey data in 4X to determine the influence of hydrographic and meteorological factors on abundance trends and catch rates incorporating hypotheses generated by discussions with fishermen. (Hurley)
7. Serve as core member to CAFSAC Surveys, Sampling and Statistics Subcommittee. (Hurley)
8. Continue analysis of juvenile haddock survey data collected in 1989 and 1990, if time permits. (McRuer, Frank, Hurley)
9. Continue thesis supervision of T. Marshall in Dept. of Oceanography, Dalhousie. (Frank)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

I. Suthers, Univ. of New South Wales (Frank); K. Brander, MAFF, Lowestoft (Hurley).

##### ii. University Liaison -

Adjunct Professor, Dept. of Oceanography, Dalhousie (Frank); Research Associate, Dept. of Biology, Dalhousie (Frank).

##### iii. Communications -

FINS at Barrington Municipal High School (Frank); Eastern Canadian Fisheries Exposition, Yarmouth (Hurley); Nova Scotia Fisheries Festival, Lunenburg (Hurley); Bedford Cub Scout tour of BIO (Frank); regional contact for CAFSAC communications initiative (Hurley).

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

O'Boyle, R.N., A.F. Sinclair, and P.C.F. Hurley. 1991. A bioeconomic model of an age-structured groundfish resource exploited by a multi-gear fishing fleet. ICES Mar. Sci. Symp. 193: 264-274.

Suthers, I.M., and K.T. Frank. 1991. Comparative persistence of marine fish larvae from demersal versus pelagic eggs off southwestern Nova Scotia. Mar. Biol. 108: 175-184.

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Hurley, P.C.F., K.T. Frank, and J. Simon. 1991. Assessment of 4X haddock in 1990. CAFSAC Res. Doc. 91/67: 48p.

##### iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

This resource is the "anchor" stock of Southwest Nova Scotia. Since 1986, it has shown limited signs of recovery, which is good news to the industry. A number of initiatives have been undertaken in 1991 which will improve stock status reliability, not least of which is the inshore survey and cooperation with fishermen. These efforts are encouraged and should lead to better assessments and new knowledge about haddock distribution.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1013

Section: Gulf of Maine

Project Title: Haddock Assessments and Associated Research 5Ze

Project Leader: Gavaris, S.

Other Researchers: Van Eeckhaute, L.; Trippel, E.; Page, F.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; haddock; assessments; assessment-related research; NAFO 5Ze

1. Project Description:

Conduct annual assessments of haddock stocks in NAFO Division 5Z, as required for management of the fishery by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into haddock biology and assessment methodology is conducted to improve the accuracy and precision of management advice. Assessment personnel participate in industry-management meetings as required to explain or elaborate assessments and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of 4VWX and 5Z haddock stocks, and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare and present an assessment of the haddock stock in unit areas 5Zjm to CAFSAC. Extend the SPA back to the 1930s if possible. (Gavaris, Van Eeckhaute, Trippel)

The haddock assessment was updated to include the most recent survey and fishery information. Results presented at CAFSAC indicated that the biomass had increased in recent years but was projected to decline due to poorer recruitment. A new innovation in the assessment this year was the derivation of a model-conditioned estimate of precision for the projected catch. Computer readable records for the fishery back to the 1930s were not located and no further progress was made on this aspect.

2. Serve on GOMAC as member for the Science Sector, Scotia-Fundy Region. (Gavaris)

Attended GOMAC meetings to provide scientific background relating to management options.

3. Conduct a comparison of the results from Y/R and SSB/R analyses for haddock in unit areas 5Zjm. (Gavaris)

No progress was made on this project due to priority being placed on estimating distribution and migration about the boundary in 5Zjm.

4. Examine the effect of depth of tow on trawl configuration using recent FRV Alfred Needler surveys. Abundance indices of 5Z haddock (and cod) will be corrected for swept area based on SCANMAR values of swept width. Measured gear spread or a known relationship of gear spread to depth will be used in lieu of a constant swept width value. (Van Eeckhaute, Strong)

M. Strong completed report of his findings. Affect on abundance indices not yet investigated.

5. Preliminary planning phase of a growth comparison study of two distinct haddock and/or cod stocks to investigate the substantially higher growth rates of Georges Bank stocks. This phase will include familiarization with topic through consultation and existing literature and investigation of suitability of capture methods and survivability through transport and holding. (Van Eeckhaute, Buzeta)

Completed a cruise on J.L. Hart to investigate capture methods and holding of live haddock. Results showed that longlined haddock survived better than trawled fish but trawling caught greatest numbers. Handling returned fish in good condition but very few were caught. Antibiotics proved very useful in increasing survival of trawled fish.

6. Preliminary preparations for a project to attempt to separate haddock stocks within the Georges Bank area based on otolith structure. Preparations to include familiarization with literature and techniques. (Van Eeckhaute)

Looked at alternate methods of capturing live haddock for tagging experiments on J.L. Hart cruise (see 5 above). Results show that survival of tagged longlined and trawled haddock was not appreciably different from untagged fish.

7. Haddock maturity stages: see Georges Bank haddock project. (Gavaris with Annand)

Gonad samples were taken during the 1991 Georges Bank Survey. After ageing the haddock, 286 slides were prepared to confirm maturity stages identified at sea and to determine maturity ogives by age and length for comparison to previous studies. This is the fourth year of an ongoing study as well as being part of a new project assessing the micro-otolith structure of one-year-old immature and mature male Georges Bank haddock.

4. Additional Accomplishments:

5. Goals/Expected Outputs for 1992:

1. Prepare an assessment of the haddock stock in unit areas 5Zjm and present to CAFSAC. (Gavaris, Van Eeckhaute)
2. Serve on Gomac as member for the Science Sector, Scotia-Fundy Region. (Gavaris)
3. Apply estimates of migration in a spatial yield model to investigate alternative harvest strategies. (Gavaris)
4. Investigate change in abundance estimates by incorporating wing spread (i.e., relationship between door spread and wing spread) data from Scanmar sensors for cruises and sets for which Scanmar data is available. Extrapolate to all sets (within survey) if possible. (Strong, Van Eeckhaute)
5. Investigate growth differences among haddock and cod populations in the Gulf of Maine area. Initiate literature search and familiarization with topic. Set up holding tanks and attempt to bring back Georges Bank haddock from surveys and other cruises or from commercial fishery. (Van Eeckhaute)
6. Investigate possibility of discriminating between Georges Bank and Browns Bank haddock and Northeast Georges and Great South Channel haddock using otolith characteristics. Apply to haddock found in Fundian Channel. (Van Eeckhaute)
7. Compile landing trends and calculate research vessel survey abundance index of 4Xs haddock. (Van Eeckhaute)
8. Develop a length at age key for 5Z haddock based on pooled age length tables and determine its validity in producing the catch at age. (Van Eeckhaute, Gavaris)
9. Continue work on reproductive biology of Georges Bank haddock. (Annand, Tripple)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -

Gavaris, S. 1991. Experience with the adaptive framework as a calibration tool for finfish stock assessments in CAFSAC. Ices C.M. 1991/D:19.

Gavaris, S., and L. Van Eeckhaute. 1991. Assessment of haddock on eastern Georges Bank. CAFSAC Res. Doc. 91/42.

Sinclair, A., D. Gascon, R. O'Boyle, D. Rivard, and S. Gavaris. 1991. Consistency of some northwest Atlantic groundfish assessments. NAFO. Sci. Coun. Studies 16: 59-77.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The Georges Bank haddock resource has undergone a remarkable recovery, in spite of intense transboundary fishing effort. This in itself is interesting considering the status of the 4TVWX haddock stocks. Project #3 will thus be very important to achieve in 1992. Generally, this project is making good progress.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1021

Section: Central Shelf

Project Title: Cod Assessments and Associated Research in Subdivision 4Vn

Project Leader: Lambert, T.

Other Researchers:

Work Activity: W.A.1.1.1.2

Key Words: groundfish; cod; assessments; assessment research; NAFO 4Vn

1. Project Description:

Conduct annual assessments for cod stocks in NAFO subdivision 4Vn as required for management of the fisheries by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into cod biology is conducted to improve the accuracy and precision of advice on management. Also participate in industry/management meetings as required to explain or elaborate assessment advice and advise on alternative management plans.

2. Long-Term Objectives:

Provide advice on management of 4Vn cod stocks and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Assessment of 4Vn cod. (a) A stock update will be prepared for the 1991 CAFSAC subcommittee meeting. (b) Preliminary work will begin on designing and implementing a system for the collection of fishing effort from inshore gear. (Lambert)

(a) A summary document was prepared and presented. (b) Fishermen have been interviewed as part of an attempt to construct a more accurate history of the fishery in recent years. It appears that official catch statistics have not revealed the true state of the fishery in 4Vn; large catches of early migrant 4T (Gulf of St. Lawrence) cod along the Laurentian Channel edge late in the year have masked the fact that catch has steadily diminished within Sydney Bight. Personal logbooks of some fishermen are being examined to try and quantitatively document this decline. Until a better knowledge of the distribution of cod stocks in the area has been gained no formal system for collection of fishing effort will be implemented. In the interim the above logbooks will serve the purpose.

2. Proposed research will concentrate on establishing the biological characteristics of the component stocks in the complex occupying the 4Vn subdivision. (a) Continue the analysis of data relating to the timing of migration of 4T cod in and out of subdivision 4Vn. (b) Begin preparation of manuscript on results of cod tagging on the eastern Scotian Shelf. (Lambert with Stobo)

(a) Completed analysis of historical data set gathered by International Observer Programme. As reported previously, sudden change in mean length of cod per set from boats fishing in NW portion of 4Vn clearly indicates arrival and departure of migrant cod. In addition, examination of tag returns on a monthly basis after release, reveals that cod leave the Gulf of St. Lawrence quite suddenly in November, and there is no slow movement of cod from west to east across the Gulf. (b) Based on a preliminary examination of the extensive data base on tagging, a manuscript giving an overview of cod movements in the Gulf of St. Lawrence and the eastern Scotian Shelf is being prepared; to be presented at the annual Canadian Conference for Fisheries Research in January, 1992.

4. Additional Accomplishments:

1. Designed, organized and implemented a new field research programme aimed at clarifying the cod stock structure and distribution in the 4Vn area (see Project #9765). (Lambert)
2. Participated as core-member of Marine Ecosystems and Environmental Subcommittee (MEES) of CAFSAC. As a member of the steering committee, was responsible for local organisation for workshop held at BIO on juvenile life stage of commercial marine species. (Lambert)

5. Goals/Expected Outputs for 1992:

1. Assessment of 4Vn cod. A stock update will be prepared for the 1992 CAFSAC groundfish subcommittee meeting. (Lambert)
2. Proposed research will concentrate on establishing the biological characteristics of the

component stocks in the complex occupying the 4Vn subdivision. (a) Collect otoliths of spawning cod for shape analysis; use these additional data for discriminant function analysis of cod stocks in 4TVW. (Lambert) (b) Begin preparation of manuscript for primary publication on results of cod tagging on the eastern Scotian Shelf. (with Stobo)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Interviewed and consulted with 15 fishermen who work mainly in the 4Vn subdivision. Close contact and ongoing consultation has been maintained with about four of these during the course of research work in the area. (Lambert)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

With the focused effort that it now has, there has been good progress on our understanding of the 4Vn cod resource. However, much still needs to be done and with limited resources, there will have to be a greater dependence on collaboration with fishermen. The most demanding short-term requirement will be for elucidation of the stock structure issue.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1022

Section: Central Shelf

Project Title: Cod Assessments and Associated Research in Division 4VSW

Project Leader: Fanning, P. (1991) ; Mohn, R. (1992)

Other Researchers:

Work Activity: W.A.1.1.1.2

Key Words: groundfish; cod; assessments; assessment research; NAFO 4VSW

1. Project Description:

Conduct annual assessments for cod stocks in NAFO Divisions 4VSW, as required for management of the fisheries by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into cod biology and assessment methodology is conducted to improve the accuracy and precision of advice on management. Assessment personnel participate in industry/management meetings as required to explain or elaborate assessment advice and advise on alternative management plans.

2. Long-Term Objectives:

Provide advice on management of 4VSW cod stocks, and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue to conduct the assessment of cod in 4VSW (1991), present assessment at CAFSAC groundfish meeting and document the results in a CAFSAC Research Document. (Fanning)

This objective was fully met and reported in Fanning & MacEachern 1991. Also, a subjective method was devised to partition the age-length keys into 4T and 4Vs components which was reported to CAFSAC.

2. Conduct the March survey of 4VSW in 1991. Continue to examine means of adjusting for the effects of not sampling strata due to ice cover. (Fanning)

The March survey was successfully conducted with 95 stations sampled. Improved means of adjusting for variable ice cover were not found.

3. Continue Index Fishing Program with NSP trawlers using IOP coverage. Extend program to include routine deployment of TDT recorders on all index sets. (Fanning)

The logistic difficulties of arranging for commercial vessels to fish fixed stations on a regular schedule proved to be insurmountable, even with a fairly high level of staff involvement over several years. This approach was concluded not to be cost effective and has been abandoned.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Conduct, and report on, the assessment of cod in 4VSW. (Mohn)
2. Conduct the March 4VSW groundfish survey in 1992. Examine the utility of this survey series in the assessment of 4VSW cod. (Mohn)
3. Investigate alternative assessment models for 4VSW cod, e.g. adaptively weighting surveys, model specification, error structure. (Mohn)
4. A multifleet multistock model will be developed for eastern Nova Scotia. It will incorporate the stock complexes of 4VW cod and include 4T cod incursion. The model will incorporate tagging data, discrimination from otolith analysis and inshore/offshore and gear specified fisheries. The adequacy of existing assessments will be examined with this model. (Mohn)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -  
Fanning, L.P., and W.J. MacEachern. 1991. Assessment of 4VSW cod in 1990. CAPSAC Res. Doc. 91/44: 42p.
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

Paul Fanning, before he left for ICOD, uncovered a significant 4T/4Vn/4VSW stock mixing issue which has since become a major issue with the industry. As well, the assessment for this, the Region's most important cod stock, has suffered from the retrospective pattern. During the coming year, the challenge will be to provide hypotheses on why the retrospective pattern is occurring and what can be done to correct for it.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1023

Section: Southern Shelf

Project Title: 4X Cod Assessment and Associated Research

Project Leader: Campana, S.

Other Researchers: Hamel, J.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; cod; assessments; assessment research; NAFO 4X;

1. Project Description:

Conduct annual assessments for the cod stock in NAFO Division 4X, as required for management of the fisheries by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into cod biology and assessment methodology is conducted to improve the accuracy and precision of advice on management. Assessment personnel participate in industry/management meetings as required to explain or elaborate assessment advice and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of the 4X cod stock, and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Produce assessment for the 4X cod stock and present it at the CAFSAC Groundfish Subcommittee meeting. (Campana)

An analytical assessment of the 4X cod stock was prepared, presented to CAFSAC, and subsequently published as a Research Document. The assessment documented a rapid shift in stock status, resulting in near-record high stock biomass levels following the record-low levels of the past several years. The change in stock status was largely due to the arrival of the extremely large 1985 and 1987 yearclasses. However, it also underlined the difficulty of predicting stock status in a recruitment fishery.

2. Serve as member of the 4X+5 Working Group. (Campana)

Represented Marine Fish Division at several meetings of the 4X+5 Working Group of the Scotia-Fundy Groundfish Advisory Committee.

4. Additional Accomplishments:

1. Served as: a) Scotia-Fundy representative on the Regional Assessment Working Group; b) core member for the MEES Subcommittee of CAFSAC. (Campana)
2. Prepared display and gave talk to students at Barrington High School as part of FINS'91. (Campana)
3. Attended meetings with fishermen in Yarmouth, Cape Sable Island, and Grand Manan to discuss current fisheries issues and to obtain comment on Science's view of stock status. (Campana)
4. Assisted in preparation of manuscript for presentation at the Workshop on Risk Evaluation and Biological Reference Points. (Campana)

5. Goals/Expected Outputs for 1992:

1. Produce assessment for the 4X cod stock and present it at the CAFSAC Groundfish Subcommittee meeting. (Campana)
2. Become familiar with the fishery, biology and assessment of cod in Division 4X. (Vacant/STABS)

6. Background:

Highlights:

Responsibility for the 4X cod assessment will be transferred to St. Andrews in FY 1992-93.

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Provided 1 newspaper and 1 radio interview on stock status; provided data and presented information on cod and haddock to students from elementary schools, high schools and universities; advised Communications Branch on groundfish pamphlet. (Campana)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Campana, S., and J. Hamel. 1991. Status of the 1990 cod fishery in 4X. CAFSAC Res. Doc. 91/48.

Doubleday, W.G., J.W. Baird, S.E. Campana, and G. Chouinard. 1991. Surplus production for cod in the southern Gulf of St. Lawrence, southwest Nova Scotia, and northeast Newfoundland, with implications for management. Workshop on Risk Evaluation and Biological Reference Points. 25 pp.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This resource has undergone a dramatic increase in recent years and, in general, is supporting the Southwest Nova Scotia inshore fishery. Dr. Campana has over the years, conducted a fine assessment of this stock. As of 1 April 1993, this assessment responsibility will be handled by St. Andrews. Dr. Capana will be redeployed to other research areas that can take advantage of his considerable expertise. During 1992, he will be cleaning up work on 4X cod assessment and facilitating transfer of the responsibility to St. Andrews.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1024

Section: Gulf of Maine

Project Title: 5Z Cod Assessments and Associated Research

Project Leader: Hunt, J.

Other Researchers: Buzeta, M.; Neilson, J.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; cod; assessments; assessment research; NAFO 5Ze

1. Project Description:

Conduct annual assessments for cod stocks in NAFO Division 5Z, as required for management of the fisheries by the Canadian Atlantic Fisheries Scientific Advisory Committee and DFO fisheries managers. Research into cod biology and assessment methodology is conducted to improve the accuracy and precision of advice on management. Assessment personnel participate in industry/management meetings as required to explain or elaborate assessment advice and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of the 5Z cod stock, and improve the quality of advice as new information or methodologies become available through research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Publish results of 4X/5Y cod stock study. (Hunt, Neilson)

Results submitted to North Amer. J. Fish. Managm. Initial reviews have been used to revise the manuscript.

2. Present results of stock assessment of 5Zj,m cod to CAFSAC, including an analysis of abundance relative to the international boundary within the management unit. (Hunt, Buzeta, Neilson)

A study to assess the abundance relative to the international boundary was presented to CAFSAC SSSS. Re-evaluation of 1978-90 catch at age was completed. Results of the stock assessment were presented to CAFSAC.

3. Participate in various groundfish advisory meetings. (Hunt)

Advisory meetings were attended.

4. Food habits of Georges Bank cod and haddock in relation to habitat disturbance caused by bottom trawling will be investigated by examination of stomach contents of fish collected during standard surveys in areas of known fishing activity and areas of low fishing activity. If appropriate, a more detailed study for 1992 will be developed. (Buzeta)

No progress due to low priority and project will not be pursued in 1992.

4. Additional Accomplishments:

Mr. Hunt was appointed Chairperson of the CAFSAC Pelagic Subcommittee. Two meetings of the Subcommittee were conducted and reported to Steering Committee. Several meetings of Steering Committee were attended.

5. Goals/Expected Outputs for 1992:

1. Present results of stock assessment of 5Zj,m cod to CAFSAC including documentation of catch at age for 1978-91. (Hunt, Buzeta)
2. Participate in various advisory and scientific information meetings. (Hunt, Buzeta)
3. Investigate methods for weighting survey indices and harvest strategies (Y/R, SSB/R, transboundary). (Hunt)
4. Publish results of cod tagging studies in the 4X/5 area. (Hunt, Stobo, Campana)
5. Chair CAFSAC Pelagic Subcommittee. (Hunt)
6. Investigate otolith characteristics (settling check, ring formation and patterns, etc.), growth

rates from lab experiments and apply results to stock identification techniques. (Buzeta)

7. Continue analysis of gear effects on probability of age at length and, if appropriate, apply to 1992 Georges Bank cod. Report results to CAFSAC. (Hunt)
8. Describe age-specific spatial distribution of Georges Bank cod in relation to the potential for movement across the Canada/U.S.A. boundary. (Hunt, Buzeta)

6. Background:

Highlights:

Expertise in stock assessment techniques was developed. (Buzeta, Neilson)

Participated in 'FINS' presentations. (Hunt, Buzeta)

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
 

Hunt, J.J., M-I. Buzeta, and J.D. Neilson. 1991. Status of the Atlantic cod stock on Georges Bank in unit areas 5Zj,m, 1978-90. CAFSAC Res. Doc. 91/41.
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

As with Georges Bank haddock, this resource has undergone a remarkable recovery. The project will continue to focus on stock distribution work until this has been completed, given the importance of this information to management strategies. Generally the project is proceeding as planned.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 103

Section: Southern Shelf

Project Title: Pollock Assessment and Associated Research

Project Leader: Annand, C.

Other Researchers: Beanlands, D.; Smith, S.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; pollock; assessments; assessment research; NAFO 4VWX; NAFO 5Zc; resource surveys

1. Project Description:

Assessment of pollock in Divisions 4VWX + Subdivision 5Zc as required for fisheries management purposes. Research into pollock biology and assessment methodology in order to improve accuracy of advice. Participation in industry management meetings to explain or elaborate on biological advice.

2. Long-Term Objectives:

Provide advice on management of pollock and improve on assessment methods as new information and techniques become available.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Produce assessment of the 4VWX5Zc pollock stock and present working paper to CAFSAC. The working paper will be upgraded to a research document. Present at FINS'91 and to SFGAC and other advisory meetings as required. Relevant CAFSAC research recommendations are: That IOP length frequencies be used to determine the age structure of the foreign fleet for next years assessment. (Annand)

The 1991 pollock was presented to CAFSAC in May 1991 and the working paper upgraded to Research Doc. 91/35. The adaptive framework was used, again incorporating only survey data as an index of pollock abundance. Biological advice was presented to SFGAC and other advisory meetings as required. Research recommendations: The age composition of the small mesh (USSR Cuba Japan) catch at age was based on Length frequencies from IOP data for the foreign fleet using small mesh gear (1981-1990), rather than using survey proportions at age as in previous years.

2. Depending on the outcome of the Dec. 1990 tagging trip, a second pollock tagging cruise is planned for the Gulf of Maine area for Dec. 1991/Jan. 1992 to expand on the numbers of pollock tagged. Fish will be alternately tagged with Canadian and American tags to determine if there is any bias associated with Canadian or American tag returns from either country. The analysis of this tagging study will be integrated with previous Scotian Shelf tagging studies. (Annand)

The 1990 pollock tagging cruise in the Gulf of Maine was not successful in locating pollock in large enough quantities to tag efficiently. Generally sets contained 1-20 pollock, and large pollock were unable to survive the haulback procedure. Pollock < than 50 cm. after some time in the holding tank were able to adjust the pressure in their air bladders and had a survival rate of about 70%. Only 72 fish were tagged 50 with American tags and 22 with Canadian tags. One return has been reported to date (U.S.A.). As a result the proposed 1991/1992 tagging cruise was cancelled.

3. After discussions with fishermen produce Tech Report based on pollock acoustic cruises. (Annand)

The technical report based on the results of the acoustic cruises was not completed due to time constraints and continued difficulties in arranging discussions with fishermen. How the fishery is managed is still their number one priority.

4. Continue pollock trap fishery study. (Annand)

Logbooks were maintained at eight sites, and Peabody Ryan temperature probes were installed at three of these. Five traps were sampled and all had length frequencies between 18 - 37 cm. (ages 1-2) with modes around 22 cm. Otoliths were taken for ageing. Again preliminary results indicate that peak catches occur in early July. Data is now being compiled and analyzed and reports will be sent to all fishermen who participated in the study. Overall fishermen were found to be very willing to co-operate but were not always consistent about keeping up the log records. Catch was usually recorded but other information, i.e. wind direction tides etc was more difficult to come by. It appears that dedicated field time as well as funding would be necessary for this program to be really successful. With the pending mandate changes this program will not be continued next year.

5. Look at changes in pollock abundance and distribution over time in order to evaluate if recent

lower abundance trends in the Gulf of Maine area are due to changes in distribution i.e. pollock are leaving American waters for cooler Canadian waters or is lower abundance in the Gulf of Maine area due simply to higher exploitation rates, collaborative study with NMFS scientist R. Mayo. (Annand)

This project is presently at about the half way point. Ten years of survey data (1980-1990) both Canadian (summer) and American (spring and fall) have been extracted using Oracle and plotted by age and yearclass using Acon and Maps (basic program that allows cumulative plotting of age and yearclass data by year). Preliminary results indicate that age may be a factor in pollock distribution.

6. Begin a cooperative program with gillnet fishermen in the Liverpool area. Initial discussions have indicated that these fishermen are very interested in keeping temperature data as well as other relevant information. More discussion is planned for sometime in January. (Hurley AFAB)

A logbook and a sea-temp temperature probe were supplied to a gillnet fisherman in the Liverpool area. Records were kept from May until October. Through this initiative contacts were made with other gillnet fishermen who would be willing to give us accurate catch, position and environmental data in order to help us understand how these processes affect the catchability and availability of commercially fished species. The data collected will be analyzed and a summary report sent to the participating fisherman.

7. Act as MFD's representative to SFGAC. Continue work on Catch Monitoring Implementation team. (Task Force)

Continued as MFD's representative to SFGAC, by attending meetings, presenting scientific advice to industry, meeting with MFD staff to discuss issues, preparing minutes, as well as providing input to the catch monitoring team as required i.e. fixed gear logs <45, etc.

#### 4. Additional Accomplishments:

1. Attended Yarmouth Fisheries Exposition (April 1991), manned booth and used the opportunity to make contacts with fishermen in the area and to discuss the 90/91 fishery. (Annand)
2. Responsible for providing to CAFSAC, (J.J. Maguire) summaries of all regional consultations with fishermen. (Annand)
3. Designated as the MFD Catch/effort Project Manager. (Annand)
4. Participation in the Northeast Fisheries center stock assessment workshop (SAW) July 10-12 1991, Woods Hole. (Annand)
5. Participation in the new Fixed Gear and ITQ committees. Because of recent changes in the management of the fishery these committees will take the place of the 4X5 and the ENS working groups. (Annand)
6. Produced pollock catch at length data (1974-1990) for both the survey and the commercial fishery in order to investigate the use of length based assessment techniques for pollock. (Annand, Mohn)
7. Participated in a pre AGAC meeting (Sept 1991) to present the draft CAFSAC advice and to obtain input to AGAC from fishermen. (Annand)
8. Collaboration with Thea Smith to produce article on survival of fish escaping from trawls. (Annand)
9. Provided Weekly Briefing note on pollock trap fishery. (Annand)
10. Catch Monitoring training (Banyan Vines Workshop) Feb. 11-15 1991. (Annand)

#### 5. Goals/Expected Outputs for 1992:

1. Produce assessment of the 4VWX5Zc pollock stock and present working paper to CAFSAC. The working paper will be upgraded to a research document. Present at FINS'92 and to SFGAC and other advisory meetings as required. Participate in the development of a process oriented approach to resource assessments (4X haddock, 4TVW haddock) (Appendix XX). (Annand)
2. Expand present industry liaison role: MFD's representative to SFGAC as well as the Fixed gear and ITQ working groups. Maintaining an ongoing liaison with Resource Allocation Branch. Coordinating Science meetings with the offshore component of the fishery. Continue work on catch monitoring implementation team as required. (Annand)
3. Continue collaborative work with NMFS scientist R. Mayo to look at changes in pollock distribution over time. (Annand)
4. As catch/effort project manager, investigate ways of getting current years data from Statistics Branch on an ongoing basis in order to get feedback from fishermen on the information collected on the new logs i.e. gear specifications, accuracy of set by set data etc. Because of problems encountered in getting data access, this project will require cooperative work with Statistics and Informatics people and training in order to fully understanding the scope and interrelationships of the data base. (McMillan, Annand)
5. Produce tech report based on pollock acoustic cruises. (Annand, Hurley)
6. Continue cooperative program with pollock gillnet fishermen. (Annand, Hurley AFAB)
7. Become familiar with the fishery, biology and assessment of pollock. (Vacant/STABS)

## 6. Background:

### Highlights:

Transfer of assessment responsibilities for pollock to St. Andrews after May 1992 assessment. (Annand)

### Selected Involvements:

#### i. Collaborative Research -

R. Mayo - pollock distributions. (Annand)

#### ii. University Liaison -

#### iii. Communications -

Filmed interview for Newsworld Today taped during Pollock Tagging Cruise (Dec. 1991) (communications). (Annand)

#### iv. Contracts Administered -

#### v. Other -

## 7. Publications:

### i. Primary -

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

Annand, C, and D. Beanlands. 1991. Assessment of Pollock (Pollachius virens) in Divisions 4VWX and Subdivision 5Zc for 1990. CAFSAC Research Document 91/35.

### iv. Popular and Miscellaneous -

## 8. Review and Evaluation:

As a result of the significant industry contacts that Ms. Annand has built over the years, the status of this stock has benefited from indirect industry input. During the coming year, this expertise will be broadened to include other sectors of the fishery, while the immediate assessment responsibility will be transferred to St. Andrews by 1 April 1993. Overall, the program is functioning well.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 104

Section: Central Shelf

Project Title: Silver Hake Assessments and Associated Research

Project Leader: Waldron, D.

Other Researchers: Showell, M. ; Koeller, P.

Work Activity: W.A.1.1.1.2

Key Words: juvenile surveys; silver hake; assessments; assessment research; NAFO 4VWX;  
foreign fishery; international observers; groundfish1. Project Description:

Conduct annual assessments of silver hake in NAFO Divisions 4VWX as required for fisheries management purposes by the Northwest Atlantic Fisheries Organization and Department of Fisheries and Oceans fisheries managers. Conduct research into the life history of silver hake to provide the basis for assessing responses of the species to its physical and biotic environment and for the improvement of assessment/management methods. Research into silver hake assessment techniques. Participation in industry/management meetings to explain or elaborate on assessments, assist in the development of a domestic silver hake fishery and to advise on alternative management plans for domestic and foreign fisheries.

2. Long-Term Objectives:

Provide advice on management of silver hake and improve on assessment methods as new information or techniques become available. Conduct research on the influence of biotic and abiotic factors on silver hake abundance indices.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Assessment of silver hake stock size in 1990. Investigate the use of length based assessment methods. (Waldron, Showell, Mohn)

The size of the silver hake stock was assessed using an adaptive framework incorporating research vessel (Waldron) and standardized commercial catch rate (Showell) indices for age 2+. The juvenile silver hake survey was used in an adapt formulation to estimate the size of the 1990 and 1991 year classes for projection of the 1992  $F_{0.1}$  catch. The question of ageing differences between Soviet and Canadian agers was again addressed. During past assessments discrepancies in the Soviet and Canadian catch at age were obvious. After many exchanges and one special session, differences in age determination were greatly reduced. At the June 1991 NAFO meeting, the question of differences in the catch at age was resolved. Since the silver hake ages and lengths are not on the divisional sampling system, new software was written to incorporate Soviet and Canadian ages with Canadian lengths to produce a combined catch at age vector for 1989 and 1990 (Waldron). Canadian sampling and ageing was used to construct the catch at age for 1977-1988. NAFO concluded that although differences in catch at age were noted, these were not significant. NAFO concentrated on the ADAPT model using ageing material and deferred any review of a length based model to future meetings.

2. Continue analysis, in preparation for publications, of data collected during a program of multi-disciplinary joint Canada-USSR research into the role of abiotic and biotic factors on commercial catch rates of silver hake. (Waldron)

All of the existing data have been received from the USSR, but new data on the contents of stomachs and ichthyoplankton are still to be received. Analysis is delayed until then. A first draft of the oceanographic interpretations has been received from Dr. Sigaev and it suggests that oceanography alone provides enough stimulus to cause silver hake to migrate onto the shelf. Work will continue on this project.

3. Continue the joint Canada-USSR silver hake juvenile surveys and present abundance indices to NAFO. (Waldron)

The Joint Canada/USSR Juvenile Silver Hake survey is proving to be more valuable as the data series lengthens. The recent NAFO STACFIS meeting was the first time that the survey was introduced in an ADAPT formulation. This gave a significant parameter estimate for year-class size at age 1. Since this stock is recruited to the fishery at age 1, estimates of the allowable catch are substantially improved as a result of this survey.

4. Compare USSR and Canadian silver hake age interpretations as contained in the exchange of otoliths collected and aged by both countries and present results to NAFO. (Waldron, Hunt)

This project was completed in the review period. All of the 1990 Canadian aged otolith samples were

sent to the ageing unit at AtlantNIRO in Kaliningrad, USSR. The results of Soviet ageing were returned to Canada in May and the data were analysed for the NAFO STACFIS meeting in June. The results show agreement between age readers between 85 and 95%. STACFIS agreed that this was sufficient to permit combining age length keys for use in the 1991 assessment for silver hake.

5. Continue analysis of radio-chemical data from silver hake otoliths to verify ageing. (Waldron, Campana, Hunt)

Project is ongoing; analysis of core samples is near completion. Ageing of samples has been done (Hunt).

6. In support of a joint Canada-USSR silver hake assessment and other collaborative projects (goals 2-4 above) with the USSR, complete a work assignment in the Soviet Union for 1-2 months. (Waldron)

Work assignment deferred until political uncertainties have been resolved.

7. Continue analysis of existing data on trophic links of cod, silver hake and haddock on the Scotian Shelf. Work in support of the ESP program and Haché Task Force Recommendations Nos. 15, 16a. (Waldron, Showell)

Work is continuing but has been given a low priority due to work loads associated with IOP.

#### 4. Additional Accomplishments:

1. Through several meetings, preparation of internal documents and analysis of Observer data, advice was provided to the industry to assist in the development of a domestic silver hake fishery. A special project to investigate the catch rates and by-catch in Emerald-LaHave Basin was initiated. The data are still being collected and have not been analysed. The intent is to determine where and when a small dragger domestic fishery could fish for silver hake. (Waldron)
2. Represented Canada (Scotia-Fundy Region) at the 1991 Canada-USSR Scientific discussions in St. John's, Newfoundland. (Waldron)
3. Placed juvenile silver hake data on ORACLE database and began editing data. (Gale, Koeller)

#### 5. Goals/Expected Outputs for 1992:

1. Assessment of 4VWX silver hake stock size in 1991. Investigate the use of other assessment methods including some of those used at ICES (eg. SHOT), and length based analysis, for this stock. (Waldron, Showell)
2. Continue to interact with the industry in developing the inshore silver hake fishery. (Waldron)
3. Complete and submit paper on silver hake diet on the Scotian Shelf. (Waldron)
4. Complete and submit paper on cannibalism in the silver hake population. (Waldron)
5. Continue the silver hake juvenile survey either as a joint Canada-USSR or solely Canadian survey. (Waldron)
6. Continue analysis of juvenile silver hake survey data to determine causes of recruitment variability. (Koeller)

#### 6. Background:

##### Highlights:

This year saw the resolution of the ageing problems between Soviet and Canadian scientists. This resulted in a combination of Soviet and Canadian data sets. This permitted a more straightforward assessment of the resource size. Also, the joint Canada-USSR juvenile silver hake surveys was included in ADAPT formulation and provided significant estimates of stock size for the 1989 year class. Also, this year saw a further improvement in the fishing for and processing of silver hake by the domestic industry. Several meetings with industry and reports provided needed input to planning for and access to the resource by the domestic industry. (Waldron)

##### Selected Involvements:

##### i. Collaborative Research -

Research continued with Dr. Sigaev of AtlantNIRO on the distribution of silver hake in relation to water mass changes along the shelf break off Nova Scotia. Studies on the use of ADAPT in the assessment of silver hake are ongoing with Dr. Gassikov of AtlantNIRO. This project is looking at the use of scaling factors for surveys used in the ADAPT formulation for silver hake. (Waldron)

##### ii. University Liaison -

##### iii. Communications -

##### iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Hunt, J.J. 1991. Comparison of Canadian and USSR estimates of age for 1989 Observer Program otolith collections. NAFO SCR Doc. 91/7, Serial No. 1879: 7pp.

Waldron, D.E., M.A. Showell, and G. Harrison. 1991. Status of the Scotian Shelf silver hake (whiting) population in 1990. NAFO SCR Doc. 91/42, Serial No. N1922: 34pp.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The Canada/USSR differences in ageing were finally resolved. In addition, there were significant improvements to the assessment. Overall, there has been significant progress on this program. However, the political uncertainties in the USSR cause concern for the future of the juvenile survey. It is important to resolve this issue in 1992. As well, the manager looks forward to the publications outlined as objectives for 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 105

Section: Central Shelf

Project Title: Redfish Assessments and Associated Research

Project Leader: O'Boyle, R.

Other Researchers: Zwanenburg, K.

Work Activity: W.A.1.1.1.2

Key Words: redfish; assessments; assessment research; NAFO 4VWX; foreign fishery;  
international observers; groundfish1. Project Description:

Conduct annual redfish assessments in NAFO Divisions 4VWX as required for fisheries management purposes by the Canadian Atlantic Fisheries Scientific Advisory Committee and Department of Fisheries and Oceans fisheries managers. Research into redfish assessment methodology and biology designed to improve the accuracy and precision of advice on management. Participation in industry/management meetings to explain or elaborate assessments and advise on alternate management plans.

2. Long-Term Objectives:

Provide advice on management of 4VWX redfish and improve on assessment methods as new information or techniques become available.

3. Goals/Expected Outputs vs. Accomplishments in 1991:4. Additional Accomplishments:

1. Prepared an assessment of 4VWX redfish status and presented this at the May 1991 meeting of the CAFSAC Groundfish Subcommittee. (Zwanenburg, Comeau)
2. Invited to participate in a workshop on age determination of Sebastes in the USSR. (Zwanenburg)

5. Goals/Expected Outputs for 1992:

No specific goals are established, but contingencies will be met.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

No further assessment activity is planned for redfish in the Scotia-Fundy Region due to an increasing focus on communication and research initiatives within the Southwest Nova groundfish fishery. The completion of the redfish age-validation study represents a significant contribution to this field in that it resolves a long-standing controversy regarding redfish longevity. See the Stock Structure Studies project for additional information.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 106

Section: Gulf of Maine

Project Title: Flatfish Assessments and Associated Research

Project Leader: Neilson, J.; Annand, C.

Other Researchers: Perley, P.

Work Activity: W.A.1.1.1.2

Key Words: flatfish; plaice; witch flounder; yellowtail flounder; winter flounder;  
halibut; NAFO 4VWX; groundfish1. Project Description:

Assessment of flatfish stocks in NAFO Divisions 4VWX and 5Z as required, including yellowtail flounder, winter flounder, witch flounder, American plaice, and Atlantic halibut stocks. Research into flatfish biology and assessment methodology designed to improve management advice. Participation in industry/management meetings as required to explain or elaborate assessments and advise on alternate management plans.

2. Long-Term Objectives:

Continue to improve the assessment of flatfish, including provision of more quantitative advice.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Completion of the halibut reproductive biology study, and preparation of a manuscript. (Neilson, Sampson)

The analyses of samples was completed this summer and the write-up of results will be completed by the end of December. First draft of a manuscript to be submitted shortly thereafter.

2. Participate in May CAFSAC Groundfish Subcommittee meetings. (Neilson)

Species summaries for 4WX flatfish and 3NOPs+4VWX halibut completed and presented at the meeting.

3. Develop an index of abundance for 3NOPs+4VWX halibut. (Neilson)

Little progress was made on this item due to more pressing research requirements. Given current data, the problem may not be tractable.

4. Completion of a manuscript describing flatfish stock structure on the Scotian Shelf. (Neilson, Stobo)

Progress has been made on this paper and the first draft of a primary publication should be available in the first quarter of 1992. The work will also be presented at the May meeting of the CAFSAC Groundfish Subcommittee.

5. Determination of winter flounder exploitation rates and stock structure in the Bay of Fundy. (Neilson, with university collaboration)

Although progress has been made towards better definition of the problem and study design, the work proceeded little further due to funding constraints, both A-based and through outside channels. However, increased industry interest in this species was evident in 1991 and university contacts have indicated an intention to initiate a study pending support through science subvention channels. Work continues to define an appropriate study.

6. Completion of the joint MFU paper describing experience with collaborative research on halibut reproductive biology. (Kearney, Neilson)

The senior author expects to complete a first draft of this paper in 1992.

7. Complete collaboration with International Pacific Halibut Commission on comparison of Atlantic and Pacific halibut biology and fisheries. (Neilson, Trumble, Bowering)

The senior author expects to complete a first draft of this paper in 1992.

8. Preparation of an invited contribution to a NATO Advanced Study Institute Meeting at Lennoxville, Quebec, 1990 devoted to Rhythmic Behaviour of Fish. The contribution will be entitled: "Rhythmic Behaviour of Marine Fish: Implications for Their Exploitation and Management." (Neilson)

Due to funding constraints from NATO, meeting sponsors were unable to fully support the attendance of Neilson. Hence, he elected not to participate in the meeting.

4. Additional Accomplishments:

1. Named Scotia-Fundy core member of Groundfish Subcommittee of CAFSAC.
2. Named Co-chair, Marine Fisheries Subcommittee of the Canadian Aquatic Resources Section of the American Fisheries Society.
3. Assisted in the development of numerous applications for the new image analyses system.
4. Served as a referee for 2 U.S. National Science Foundation Grant Proposals.
5. Provided reviews of manuscripts (8 externally, 6 internally).
6. Served on Atlantic Reference Centre Steering Committee.
7. Assembled speakers for theme session of 1992 CCFR meeting, Halifax.
8. Participate in FINS and related activities. Participated in AGAC Atlantic Halibut Working Group meeting (Halifax), meeting regarding winter flounder with <45' generalists (Lower Weymouth), meeting with mobile gear <65 (Yarmouth) and Enforcement Officers (Yarmouth).
9. Completed collaboration with International Pacific Halibut Commission on comparison of Atlantic and Pacific halibut biology and fisheries (Neilson, Trumble, Bowering). The work has cleared internal review. It will be submitted to Can J. Fish. Aquat. Sci. for publication as a Bulletin or Special Publication.

5. Goals/Expected Outputs for 1992:

1. Submit manuscript on halibut reproductive biology. (Neilson, Kearney)
2. Submit manuscript on flatfish stock structure as primary publication and working paper at May CAFSAC. (Neilson, Stobo)
3. Completion of the joint MFU paper describing experience with collaborative research on halibut reproductive biology. (Kearney, Neilson)
4. Through the ITQ Working Group investigate ways of obtaining catch information by species for Scotian Shelf flatfish (if time permits). (Annand)

6. Background:

Highlights:

Completion of the comparison between Atlantic and Pacific halibut was a highlight of this year.

Selected Involvements:

- i. Collaborative Research -  
International Pacific halibut Commission  
Maritime Fishermen's Union
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

Research has primarily focused on halibut with flatfish work consisting of examination of stock structure. With the changing mandate sharing between BIO and STABS, there may be opportunities to enhance work on these increasingly valuable species. Generally, progress has been as good as can be expected.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 107

Section: Central Shelf

Project Title: Continental Shelf Margin Studies Including Argentine Assessment

Project Leader: Halliday, R.

Other Researchers:

Work Activity: W.A.1.1.1.2

Key Words: Argentine; deep water fauna; underutilized species; mesopelagic assessments; assessment research

1. Project Description:

Stock assessments and research into the biology of Atlantic argentines. The project also provides a focus for study of the biology and ecology of fish species along the continental shelf edge and in adjacent oceanic waters, particularly in the slope water region. It promotes the exploration of inter-relationships of neritic and oceanic systems and, in taking a broader view, may help to explain events observed in continental shelf fish resources while elucidating commercial potential of slope and oceanic resources such as saury, macrourids, and myctophids.

2. Long-Term Objectives:

Provide a basis for rational management of Atlantic argentine. Provide knowledge of fish production along the edge of the continental shelf and in adjacent oceanic waters, and of the commercial potential of these resources. Describe the inter-relationships between off-shelf and on-shelf ecological systems with regard to fishes. Examine the potential of exotic forms as indicators of environmental variability and trends.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. The fish and associated oceanographic data collected during the series of mesopelagic faunal surveys conducted in 1988-89 will be analyzed with regard to taxonomic composition of the ichthyofauna, temporal and spatial variations in its distribution and abundance, and the relationships between dominant species and physical oceanographic features. (Halliday)

Oceanographic data summarization is now complete and available for incorporation in analysis of fish distributions. In 1991, work on fish distributions (by doctoral student D. Themelis) concentrated on evaluation of statistical techniques for use in analysis of fish data. Detrended Correspondence Analysis has been chosen as an ordination technique, with interpretive support being provided by Two Way Indicator Species Analysis. Initial results indicate that most of the observed variance in species composition is, as expected, accounted for by water mass characteristics.

2. Based on the contract report on the commercial potential of deep-sea species, decisions will be made on which, if any, species deserve further investigation. If there are such species, gear acquisition and field trials will be initiated. The Fisheries Development Division of FHMB will be the lead agency throughout this project. (Halliday)

The contract report from ARC, St. Andrews, N.B., commissioned in 1990, was received early in 1991. This indicated that crustaceans, particularly continental slope shrimp species, offered the greatest immediate development potential, and proposed that the advantages of using fixed gears, rather than trawls, for exploration and development be investigated. Part of cruise N156 in August was devoted to fishing trials with shrimp and crab traps, gillnets and longlines at depths between 485 and 2800 m at two locations off the Scotian Shelf. Gear deployment and retrieval was highly successful. Catches were composed of 21 species of fish, and red deep-sea crab were common to depths of 1300 m south of Emerald Bank. However, almost no shrimp were caught and further investigation is required to determine the reason for this disappointing result.

3. Efforts will be continued to put 'rare fish' collection by the IOP on a systematic basis. (Halliday)

Trials of a systematic collection system during the Japanese tuna fishery in 1990-91 provided insights into the opportunities and problems connected with utilization of the IOP to obtain quantitative data on rare fish occurrences. Disruption of the IOP as a result of changes in contractors, and in technical support as a result of extended leaves of absence, made 1991 an appropriate time to pursue this initiative further. It has not yet proved possible to develop a feedback mechanism to observers on identity of specimens in an acceptable time frame.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. The analysis of mesopelagic fish distributions, based on data from 1988-89 Slope Water cruises, will be brought to completion (by graduate student D. Themelis). (Halliday)
2. A report on the stock status of Atlantic argentine will be prepared for CAFSAC, if requested by the Committee. (Halliday)
3. \*Rare fish\* collected through IOP, or other sources, will be received and curated, and mechanisms will be sought to feedback identifications to collectors on a shorter timeframe. (Halliday)

6. Background:

Highlights:

Selected Involvements:

## i. Collaborative Research -

Mesopelagic fish research with D. Themelis, Dalhousie University; commercial potential of deep-sea species in collaboration with C. Cooper and W. Hickey, Fisheries Development, FMB, Halifax. (Halliday)

## ii. University Liaison -

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

7. Publications:

## i. Primary -

Halliday, R.G. 1991. Marine distribution of the sea lamprey (Petromyzon marinus) in the northwest Atlantic. Can. J. Fish. Aquat. Sci. 48: 832-842.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

Halliday, R., and C. Cooper. 1991. Exploration of deepwater resources off the Scotian Shelf. DFO Scotia-Fundy Region, Halifax, N.S., Project Summary No. 32, Dec., 1991: 4pp.

8. Review and Evaluation:

This project represents the Division's sole involvement in shelf margin and deepwater faunal studies. This work is essential to a complete understanding of our bio-economic zone and its continuation is to be encouraged.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 108

Section: Marine Mammals

Project Title: Population Ecology of Sealworm

Project Leader: McClelland, G.

Other Researchers: Martell, J.

Work Activity: W.A.1.1.1.7

Key Words: seals; marine mammals; sealworm; parasitology; Sable Island; Seal-Sealworm Ecology Program

1. Project Description:

Population dynamics of anisakine nematodes (sealworm and related species) in invertebrates, fish, and marine mammal hosts.

2. Long-Term Objectives:

Monitor geographic variation and temporal trends in prevalence and abundance of sealworm in fish and marine mammal hosts. Determine host-parasite interactions and intra- and inter-specific parasite interactions that influence the survival and reproductive potential of sealworm in the gastrointestinal tract of the seal host. Identify invertebrate hosts of the sealworm larvae among the benthic and epibenthic macrofauna and attempt to quantify abundances of parasite therein.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete and submit for primary publication manuscripts on i) multivariate analyses of nematode infections in the gastrointestinal tract of grey and harbour seals from the Gulf of St. Lawrence, eastern Nova Scotia, and the lower Bay of Fundy (McClelland, Martell, Misra); and ii) discriminant analyses of nematode infections in Gulf and Atlantic grey seals. (McClelland, Martell, Misra) (A-base)

Preparation of the manuscripts above was delayed as a consequence of (1) time lost to the strike (2) unforeseen expenditures of time on consultations (SP-C-4) and on organization and preliminary analyses of data from the 'Seal Prey Survey' (P-6) and (3) time devoted to unscheduled activities such as the collection and preservation of material for a study of sealworm morphometrics (AA-1), the preparation of documentation for an interregional 'Parasitology Planning Workshop' (AA-2) and opportunistic collaboration on a manuscript with D.J. Marcogliese of IML (AA-3). In addition to the collaborative study which has been accepted for primary publication, final draft manuscripts on 1) transmission of larval sealworm from crustacean to fish host and 2) coccidiosis in harbour seals from Sable Island were completed and are now under internal review (AA-4). Some progress was also made on the preparation of a manuscript on the geographical distribution of microsporidians infecting the flesh of American plaice (AA-5).

2. Begin preparation of manuscripts on i) long-term temporal variations in prevalence and abundance of sealworm in cod and American plaice in eastern Canada (McClelland, Martell); and ii) temporal and geographical variations in prevalence and abundance of sealworm in American plaice: 1957-1990. (McClelland, Misra, Martell) (A-base)

Work on manuscripts arising from ongoing sealworm surveys was deferred as a result of time lost to the strike or devoted to other projects, commitments and previously unscheduled activities (see P-1).

3. Complete an assessment of the efficiency of our routine examinations of fish for parasitic nematodes. (McClelland, Martell) (A-base)

The results of this project exceeded expectations and, through the employment of a student (COSEP) rather than a contractor, it was completed for less than half of the projected cost. The flesh of individual cod, plaice, sculpin, etc., (total n=350) was subjected to pepsin-HCL digest following routine inspection for sealworm using slicing and candling procedures. Our routine inspections of scrod and plaice proved to be nearly 100% efficient, but overlooked 10% of the nematodes in the flesh of market cod.

4. Continue involvement in Dalhousie anthelmintic and immunological studies. (McClelland) (A-base)

Much progress was made in the formulation of liposome delivery vehicles which promote sustained release of efficacious levels of anthelmintics or antigenic preparations. Further, an antigenic 45 kd sealworm protein was fully sequenced and identified as haemoglobin from the pseudocoelomic fluid of the nematode; the efficacy of the purified haemoglobin and of an allergenic 10 kd protein from the sealworm pseudocoel are currently being tested in captive grey seals. Finally, an immunocontraceptive approach involving injection with a liposome-zona pellucida (ZP)-Freunds complete

adjuvant (FCA) formulation has elicited what appear to be efficacious serum titres of antibodies.

5. Complete data entry and analyses of larval anisakine infections in seal prey. (McClelland, Martell) (B-base)

Data on larval anisakine infections in >9000 fish, belonging to 38 species from the Breton Shelf, Sable Island Bank and southwestern Nova Scotia were mounted on the computer. Following summarization of infections by host species and size and preliminary analyses, some of the data was included in a manuscript (Marcogliese and McClelland) (AA-4) accepted for primary publication. The work was completed without the participation of a contract statistician (projected cost, \$9.0 K).

6. Prepare for primary publication, manuscripts on i) a comparative study of the diets of three co-occurring species of flatfish, Limanda ferruginea, Pseudopleuronectes americanus and Hippoglossoides platessoides, from Sable Island Bank; ii) the relationship between diet and nematode infection for three species of flatfish, Limanda ferruginea, Pseudopleuronectes americanus and Hippoglossoides platessoides, from Sable Island Bank. (Martell) (B-base)

Drafts of manuscripts on: 1) Diets of each of three co-occurring species of flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus, from Sable Island Bank; 2) Comparisons among the diets of three co-occurring species of flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus, from Sable Island Bank; and 3) Host diet and the transmission of the anisakine nematode, Pseudoterranova decipiens, between intermediate hosts, from benthic macroinvertebrates to flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus; have been completed.

#### 4. Additional Accomplishments:

#### 5. Goals/Expected Outputs for 1992:

1. Complete and submit for primary publication manuscripts on i) multivariate analyses of nematode infections in the gastrointestinal tract of grey and harbour seals from the Gulf of St. Lawrence, eastern Nova Scotia, and the lower Bay of Fundy (McClelland, Martell, Misra), ii) discriminant analyses of nematode infections in Gulf and Atlantic grey seals (A-base) (McClelland, Martell, Misra).
2. Flatfish diet - Complete and submit for primary publication i) "Diets of each of three co-occurring species of flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus, from Sable Island Bank"; ii) "Comparisons among the diets of three co-occurring species of flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus, from Sable Island Bank"; and iii) "Host diet and the transmission of the anisakine nematode, Pseudoterranova decipiens, between intermediate hosts, from benthic macroinvertebrates to flatfish, Hippoglossoides platessoides, Limanda ferruginea, and Pseudopleuronectes americanus" (regional A-base) (Martell, McClelland).
3. Begin preparation of manuscripts on i) long-term temporal variations in prevalence and abundance of sealworm in cod and American plaice in eastern Canada (McClelland, Martell), ii) temporal and geographical variations in prevalence and abundance of sealworm in American plaice: 1957-1990 (A-base) (McClelland, Misra, Martell).
4. Continue involvement in Dalhousie anthelmintic and immunological studies (A-base) (McClelland).
5. Collect and preserve additional sealworm larvae from small benthophagous fish (fourbeard rockling, hookear sculpin and alligatorfish) for morphometric study on a dedicated cruise in June 1992 (McClelland, Martell).
6. Begin measurements of body lengths and other characteristic dimensions of sealworm larvae from benthophagous and piscivorous fish for morphometric comparisons (regional A-base) (McClelland).
7. Collect (on the dedicated cruise above) and maintain infected juvenile plaice (2-3 years old) for a study of sealworm longevity in fish hosts (regional A-base) (McClelland).
8. Complete identification and enumeration of anisakine nematodes from the remainder of Sable Island grey seal sample (n=66) and from 200-300 grey and harbour seals sampled off eastern Nova Scotia and in the lower Bay of Fundy (B-base (AFAP)) (McClelland, Martell).
9. Continue survey of anisakine infections in recently weaned grey seals from the Sable Island breeding colony (McClelland, Beck, Martell).

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

R.K. Misra, Physical and Chemical Sciences Branch, statistical analyses of nematode infections in marine fish and seals; Sealworm Working Group (W.C. Kimmins, Dean of Science, Dalhousie University), biological methods for sealworm control; C.M. Morrison, Benthic Fisheries and Aquaculture Division, microsporidean infections in flatfish; Fish Inspection Branch, parasite problems in seafood; W. Pohajdak, Biology Department, Dalhousie University, genetic variation in anisakine nematodes and serological screening of fish for anisakine infection; D. Marcogliese, IML, benthic surveys and larval helminth infections in fish. (McClelland)

## ii. University Liaison -

DFO liaison officer for two continuing DFO/NSERC Science Subvention projects; M.D.B. Burt, University of New Brunswick, Fredericton, N.B., Determination of the sibling status of Pseudoterranova decipiens using iso-electric focusing and morphology - \$9.0K; D.K. Cone, St. Mary's University, Halifax, N.S., The taxonomy and geographical distribution of Anguillicola in eels (Anguilla rostrata) of Nova Scotia - \$8.2K. (McClelland)

## iii. Communications -

Provided literature and research updates on anisakine nematodes in marine mammals and fish for Greenpeace International and the U.S. Food and Drug Administration; identified mature (Eubothrium sp.) and larval (Diphyllobothrium plerocercoid) tapeworm infections in salmon and brook trout for Nutrition and Disease Section (BFAD); provided identifications and background information on microsporidian (Loma morhua) and larval nematode (Anisakis and Pseudoterranova spp.) infections in Pacific cod filets for Vice-President - Quality Management, National Sea Products Ltd.; provided identifications and background information on fungal nodules (Cladosporium and Penicillium spp.) in Western Bank scallop meats for Inspection Services, Lunenburg (material forwarded to D. Strong, St. Mary's University for specific identification); inventoried parasitic infections (including the microsporidian Glugea sp., the trematodes Podocotyle atomon, Lecithaster gibbosus, Cryptocotyle lingua and Stephanostomum baccatum and the nematode Hysterothylacium sp.) in winter flounder from the BIO aquarium for Habitat Ecology; identified and provided background information on nematode (Anisakis and Hysterothylacium) infections in gaspereau for Freshwater and Anadromous Division; identified and provided background on fungal (Ichthyophonus sp.) nodules in Scotian Shelf cod filets for National Sea Products Ltd., Lunenburg, N.S.; identified and provided background on sealworm infection in "western red snapper" for Inspection Services, Central and Arctic Region, Toronto, in response to a consumer complaint. (McClelland)

## iv. Contracts Administered -

P. Pocklington, identification of polychaetes from flatfish stomachs - \$5.0K; Dr. Gwyneth Jones, Identification and enumeration of nematodes from seal stomachs - \$42.0K. (McClelland)

## v. Other -

7. Publications:

## i. Primary -

Marcogliese, D.J., and G. McClelland. 1992. Corynosoma wegneri (Acanthocephala: Polymorphida) and Pseudoterranova decipiens (Nematoda: Ascaridoidea) larvae in Scotian Shelf groundfish. Can. J. Fish. Aquat. Sci. 49: 0000-0000 (in press).

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

McClelland, G., and D.J. Martell. 1991. Geographical distribution of the microsporidian parasite Pleistophora hippoglossoides in American plaice Hippoglossoides in eastern Canada. Regional Fish Health Workshop, 6-8 November 1991, Halifax, N.S. (Abstract)

McClelland, G., D.J. Martell, and C. Morrison. 1991. Distribution Pleistophora hippoglossoides in American plaice (Hippoglossoides platessoides) in eastern Canada. Meeting of the Atlantic Association of Parasitologists, Institut Maurice Lamontagne, 4 October 1991.

8. Review and Evaluation:

Progress against program objectives has been good.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1091

Section: Marine Mammals

Project Title: Seal Diet and Energetics

Project Leader: Bowen, D.

Other Researchers:

Work Activity: W.A.1.1.1.4

Key Words: seals; marine mammal/fisheries interactions; diets; food consumption; energetics; Seal-Sealworm Ecology Program; sealworm

1. Project Description:

Research on the foraging ecology and population energetics of grey and harbour seals on the Scotian Shelf and in the Bay of Fundy. Studies to determine the nature and extent of interactions between these species and commercial fisheries.

2. Long-Term Objectives:

Provide a better understanding of the seasonal food requirements and diets of the grey and harbour seal population in the Scotia-Fundy Region to serve as the basis for management advice on seal/fisheries interactions including the transmission of the sealworm parasite and competition for fish. Provide a broader base for comparative studies with other seal species elsewhere in the world.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Quantitative analysis of seasonal variation in the diets of harbour seals in the Bay of Fundy from samples collected between 1988-1990 and submission of paper for primary publication. (Bowen)

Recovery, identification, and measurement of fish otoliths and squid beaks from 220 harbour seal stomachs collected to date have been completed. Data have entered into a computer data base for final analysis.

2. Collection of grey and harbour seal faecal samples on Sable Island to determine seasonal variation in offshore diets. (Bowen)

Faecal samples from grey (153) and harbour seals (200) on Sable Island have been collected quarterly to determine seasonal variation in offshore diets. Based on past studies it is clear that most seals on Sable Island have no food in their stomachs when they haul out. Thus, faecal samples currently provide the only means of determining offshore diets.

3. Quantitative analysis of seasonal and geographic variation in grey seal diets from coastal samples collected between 1988-1990. Data entry and editing will be the major activities. Supplementary by contract hunters to fill gaps in the data set. (Bowen)

Five hundred twenty-eight grey seal stomachs, representing all existing samples collected between 1988 and 1990, were analyzed to determine diets on the Scotian Shelf. The results show marked differences in summer and winter diets at both inshore and offshore locations. These data also clearly indicate that young fish are usually eaten by grey seals and that at any one time only 3-5 species comprise most of the diet.

4. Complete a study on Sable Island of the foraging energetics of harbour seal mothers during lactation in relation to female body size. (Bowen)

A three-year field study of the foraging energetics of adult female harbour seals was completed on Sable Island. In May 1991, 13 adult females were equipped with time-depth recorders to measure diving behaviour and were given deuterium oxide (a stable isotope of water) to measure water turnover. Coupled with information on the water content of prey, these water turnover data will be used to estimate the amount of food eaten by seals in their natural environment. Combined isotope and TDR data were obtained from 11 of the 13 seals over most of the 24 day lactation period.

5. Measure metabolic rate of adult female grey seals on Sable Island, using doubly-labelled water, to determine total energy expenditures over the lactation period. (Bowen)

This project had to be deferred because the only suppliers of the oxygen-18 isotope were unable to deliver our order. The work will be completed in January 1993 or 1994 when the isotope becomes available.

6. Continue the collection of longitudinal data to determine how reproductive success of known-age

grey and harbour seal females on Sable Island varies with age and physiological condition. (Bowen and Stobo, authors listed alphabetically)

During the May-June 1991 period, reproductive data were collected from 98 tagged harbour seals ranging in age from 4-13 years. Pup growth rates and the condition of adult females were also monitored as a means of assessing trends in food availability.

7. Initiate a long-term study on the offshore feeding behaviour of adult grey seals. The objective is to determine the location and frequency of diving behaviour to provide an estimate of feeding activity and the overall activity budget of adults. This information is essential to calculate reliable estimates of energy expenditure and thus food requirements. In May 1991, two satellite tags will be deployed on newly moulted grey seal males. The tags transmit data on the diving behaviour and haul-out patterns to the Argos polar orbiting satellite. (Bowen, Stobo, and Beck)

In May 1991, 4 adult grey seals were immobilized and equipped with mock satellite transmitters to test attachment methods. We expect to observe these seals on Sable Island in January 1992. Suppliers and availability of both satellite and conventional time-depth recorders were determined and orders placed for several devices.

8. SSEP program coordination meetings. (Bowen and Beck)

A meeting is planned for March 1992.

9. Attend and present a paper at the 9th Biennial Conference on the Biology of Marine Mammals, Chicago, December 1991. (Bowen)

Approval to attend this conference was not granted.

#### 4. Additional Accomplishments:

1. Member of NSERC Grant Selection Committee of Evolution and Ecology. (Bowen)
2. Served as a member of an external international panel to review the marine mammal programs of National Marine Fisheries Service, Woods Hole, MA in July 1991. (Bowen)
3. Invited to join external panel to review research programs of the National Marine Mammal Laboratory, Seattle, WA in September 1991. (Bowen)
4. The following papers were submitted for publication:

Bowen, W.D., J. Lawson, and B. Beck. Seasonal and geographic variation of grey seal diets on the Scotian Shelf: implications for seal-fisheries interactions. *Can. J. Fish. Aquat. Sci.*

Ross, P.S., and W.D. Bowen. Changes in clinical chemistry in harbour seal (*Phoca vitulina*) mothers and their pups during lactation. *Can. J. Zool.*

Ross, P.S., B. Pohajdak, W.D. Bowen, and R.F. Addison. Immune function in free-ranging harbour seal mothers and their pups during lactation. *J. Wildl. Diseases.*

Ross, P.S., I.K.G. Visser, M.W.G. van de Bildt, W.D. Bowen, and A.D.M.E. Osterhaus. Phocine distemper virus enzootic in Canadian seals: Implications for the European outbreak of 1988. *The Veterinary Record.*

Boness, D.J., W.D. Bowen, and S.J. Iverson. Selective advantage of reproductive synchrony in a polygynous mammal: A new hypothesis. *Anim. Behav.*

S.J. Iverson, W.D. Bowen, D.J. Boness, and O.T. Oftedal. Maternal mass loss, milk energy output, and pup growth over lactation in grey seals. *J. Zool. (Lond.).*

#### 5. Goals/Expected Outputs for 1992:

1. Collect and analyze grey and harbour seal faecal samples from Sable Island to monitor seasonal and interannual variation in offshore diets. (Bowen)
2. Complete analysis of harbour seal diets in the Bay of Fundy area based on the analysis of stomach content data from 1988 and 1989 and submit the results for publication. (Bowen)
3. Incorporate new data on diets into population models to obtain better estimates of the fish mortality rates cause by seals. (Bowen with Mohn)
4. Determine vital rates, such as reproductive success and adult survival, from known-age harbour seals on Sable Island. (Bowen with Stobo)
5. Continue the collection of long-term data on the reproductive success and survival of known-age cohorts of grey seals on Sable Island. (Bowen with Stobo)
6. Determine the frequency and location of offshore feeding areas of adult grey seals using a combination of Time-depth Recorders and Satellite Transmitters. (Bowen with Stobo)
7. Determine seasonal and age-related changes in the energy content of selected seal prey species using specimens collected for the development of otolith size-fish size relationships and an otolith identification key. (Bowen with Campana)

#### 6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project represents the energetics and diet component of the SSEP initiative. Thus far, progress has been steady, in large part due to steady, relatively stable funding. As with Project 1080, the overall initiative appears on track and will hopefully reach a successful conclusion in 1994/95.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1092

Section: Marine Mammals

Project Title: Seal Population Dynamics

Project Leader: Stobo, W.

Other Researchers:

Work Activity: W.A.1.1.1.4

Key Words:

1. Project Description:

Research on the population biology and dynamics of grey and harbour seals in Atlantic Canada with particular emphasis on the Scotian Shelf. Assessment of population status of grey and harbour seals and provision of biological advice to managers as required.

2. Long-Term Objectives:

Improve knowledge of grey and harbour seal biology, population structure, and trends to provide a basis for the sound management of these species, to obtain a better understanding of the interactions between seals and fisheries, and to provide a broader base for the comparative study of pinniped ecology.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Tag 1991 cohort of harbour seals, enumerate dead and estimate annual production on Sable Island. Continue development of a brand resighting data base for the 1988, 1989, and 1990 branded harbour seal cohorts. (Stobo)

A total of 595 harbor seal pups were tagged in May-June 1991. Over 100 observations were made of branded harbor seal juveniles. A data set on harbor seal brand resighting was created and observations (1988-91) by both DFO and external personnel entered and edited)

2. Continue systematic recording of branded grey seal sightings on Sable Island and initiate analysis of brand resighting data to estimate survival rates. (Stobo)

With the recruitment of 3 new branded cohorts more brand resightings were made than in previous years; over 1000 resightings were made. A contract has been let (Carl Schwarz) to develop probability functions associated with non-return and sporadic sightings of animals.

3. Prepare manuscript on growth in harbour seal pups from birth to age 3. (Stobo, Horne (non-DFO), Smith)

Data analysis completed but manuscript preparation not yet commenced.

4. Complete paper on tag loss in grey seals. (Stobo, Horne (non-DFO))

Manuscript completed and submitted to J. Wildlife Management; revisions completed and paper re-submitted.

5. Initiate a pilot study to examine genotypic differences within and between in grey seal populations. (Stobo)

Blood samples of males taken on Sable; preliminary DNA runs indicated better sample preparation would improve results.

6. Attend, and present paper at, the 9th Biennial Conference on Marine Mammals. (Stobo)

Verbal paper presented on reproductive success of young female grey seals. (Bowen and Stobo)

4. Additional Accomplishments:

1. Paper on growth of grey seal pups and maternal investment accepted by J. Zool. (Bowen, Stobo, Smith)
2. Paper on organochloride residues in grey seal pups submitted to J. Zool. (Addison and Stobo)
3. Analysis of grey seal tagging data to examine mark-recapture estimation based on timing of tag application and recovery in preparation. (Schwarz/Stobo)

4. Conducted study on post-weaning fast of grey seal pups. One hundred pups were monitored after weaning until they left the Island. (Stobo)
5. Initiated joint study (with Bowen) on reproductive strategy and success of grey seals - consists of weighing mothers of various ages and their pups at birth and near weaning to document weight changes in both mothers and pups through the lactation period. We are using only branded females so their age is known and we will be able to follow each individual over several years to monitor their personal histories. Approximately 60 mother-pup pairs were studied in 1991.

5. Goals/Expected Outputs for 1992:

1. Continue analysis of grey seal brand resighting data to estimate survival rates. (Stobo)
2. Continue systematic recording of branded grey seal sightings on Sable Island. (Stobo)
3. Continue helicopter survey of Bay of Fundy of harbor and grey seals to obtain a ratio of species mix and continue collection of time series data on harbor seal numbers for an index of abundance. (Stobo)
4. Initiate project to examine pathological effects of hot iron branding on juvenile seals, and investigate alternative methods. (Stobo)
5. Tag 1992 cohort of harbour seals, enumerate dead and estimate annual production on Sable Island. Continue collection of harbor seal brand resighting data. (Stobo)
6. Initiate analysis of otolith dissolution experiment. (Stobo)
7. Prepare manuscript on growth in harbor seal pups from birth to age 3. (Stobo, Horne (non-DFO), Smith)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

Joint work with Physical & Chemical Sciences Branch scientist (R. Addison) on pollutants in grey seal juveniles. (Stobo)

ii. University Liaison -

Joint work with University of Manitoba researcher (C. Schwarz) on theoretical aspects of mark recapture estimates. (Stobo)

iii. Communications -

iv. Contracts Administered -

Contract to develop probability functions associated with non-appearance of branded grey seals on the breeding grounds (\$4k); Contract to examine fatty acid composition in juvenile grey seals as a possible indicator of growth energy sources (\$10k). (Stobo)

v. Other -

Reviewed 1 paper for Marine Mammal Science. Gave a presentation on seals to two groups of 'gifted' students (25 in total) selected from 19 Dartmouth Elementary Schools on seals and interactions with man. Also gave a presentation on biotic interactions, using seals as an example, to grade 7 students from Herring Cove Jr. High School. (Stobo)

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Progress on this project has been good and with Project 1080 and Project 1091 represents a solid contribution to our understanding of seals in the Scotian Shelf ecosystem.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1093

Section: Marine Mammals

Project Title: Seal Research Infrastructure

Project Leader: Bowen, D.

Other Researchers: Stobo, W.

Work Activity:

Key Words: seals; Sable Island; all terrain vehicles; field stations

1. Project Description:

Provides support for the research and assessment programs on grey and harbour seals conducted by Marine Fish Division on Sable Island by maintaining field stations and vehicles in good working order.

2. Long-Term Objectives:

To provide and maintain the infrastructure on Sable Island to enable Marine Fish Division scientists to carry out research programs on grey and harbour seals.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Maintain in good working order 10 all terrain vehicles (ATV) for use in January/February, May/June field seasons. (Bowen)

Routine maintenance was done on all terrain vehicles during the May 1991 grey and harbour seal field work and again in September in preparation for the January grey seal field work.

2. Make arrangements for the return of the Section's tractor to Sable Island. (Bowen)

The section's refurbished tractor was returned to Sable by DOT ship in May 1991. The tractor was used extensively in September to re-supply our East Light field camp.

3. Order and ship to Sable Island gasoline and propane required for the field programs planned for the coming fiscal year. (Bowen)

Twenty-five barrels of gasoline and 9 bottles of propane were shipped to Sable Island by DOT ship in May 1991.

4. Order and ship to Sable Island food to provision base population monitoring programs. (Bowen)

Both East and West Light camps were supplied with food for the May and January field seasons.

5. Charter flights to Sable Island to enable basic population research to be conducted. (Bowen)

Twelve charter flights were scheduled to meet programs requirements for grey and harbour seal population monitoring research on Sable Island.

6. Repair or replace as necessary the fence at the East Light camp. (Bowen)

About 60% of the fence was replaced at the East Light camp.

7. Perform routine maintenance on buildings; including the replacement of damaged windows at East Light. (Bowen)

Repairs were done on several East Light buildings to repair minor damage caused by several severe storms in October 1991.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Maintain in good working order 10 all terrain vehicles (ATV) for use in January/February, May/June field seasons. (Bowen)

2. Order and ship to Sable Island gasoline and propane required for the field programs planned for the coming fiscal year. (Bowen)

3. Order and ship to Sable Island food to provision base population monitoring programs. (Bowen)
4. Charter flights to Sable Island to enable basic population research to be conducted. (Bowen)
5. Repair or replace as necessary the fence at the East Light camp. (Bowen)
6. Complete replacement of fence around East Light camp. (Bowen)
7. Perform routine maintenance on buildings; including the replacement of damaged windows at East Light. (Bowen)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

In 1990/91, it was decided to explicitly define the seal program's support costs. These have averaged about \$33K since 1989/90. In 1992/93 and beyond, as budgets reduce, there will have to be a means by which support program costs can be minimized. Thus far, however, this particular program has been efficiently managed.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 110

Section: Central Shelf/Gulf of Maine

Project Title: Groundfish Management Research

Project Leader: Halliday, R.

Other Researchers: Fanning, P.; Gavaris, S.; Mohn, R.; Hunt, J.; Showell, M.; Stephenson, R.; Waldron, D.

Work Activity: W.A.1.1.1.2

Key Words: assessment research; groundfish

1. Project Description:

This project conducts research and analyses relevant to the evaluation of current fisheries management strategies and procedures and to the development of alternatives. Orientation is towards the study of fisheries and the interaction among fish, the fishing industry and management regimes. Cooperation between the biological and economic, regulatory and enforcement functions within the Region is fostered by providing biological support to joint projects and long-range planning activities.

2. Long-Term Objectives:

To provide the scientific basis for improvements in management approaches based on analysis of the effects of current strategies; to work cooperatively with other groups concerned with management to integrate biology with socio-economic and regulatory elements, and thus provide a technically rigorous procedure for management planning; to advise on improvements in data collection and analysis programs of relevance to the Division in support of new management initiatives.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Comparisons of North Atlantic fishery management regimes subsequent to extensions of jurisdiction -- a descriptive account will be prepared suitable for a lay audience and as a basis for subsequent analytical work. (Halliday)

Progress has been made in writing this report but other, more urgent, projects were given priority.

2. An account will be prepared of the development of regional groundfish fleet overcapacity within the context of annual management (catch quota) plans and vessel licensing policy, summarizing aspects of research over the past 5 yrs on the fleet capacity problem. (Halliday)

A manuscript was prepared and reviewed but preparation of a final version was postponed due to other priorities.

3. Comparative analysis of different management systems. Continue development of multifleet, multispecies version of program with increased emphasis on economics and within year events, and possibly EAs. (Mohn)

Work within this project was focused on integrating the vessel performance information into the overall model. This was done for 4VsW cod, 4X cod and 4X haddock and reported at the IV Interdisciplinary Conference of Natural Resource Modelling and Analysis, Barcelona, July 15-18, 1991 (Mohn, Bio-economics of mesh change in gadoid fisheries on the Scotian Shelf). Also, a working paper was presented to CAFSAC (Mohn, Examination of the potential effects of a mesh change to Scotian Shelf fisheries) and a briefing note on this same topic was prepared for the Regional Director, FHMB (Halliday and Mohn, Briefing on effects of mesh size increase in Scotia-Fundy Region cod fisheries).

4. The Biological and economics feedback control model based on Scotian Shelf groundfishing was developed in 1989/1990. It will be written up and submitted to the primary literature. (Mohn)

This model was further refined and reported at the IV Interdisciplinary Conference of Natural Resource Modelling and Analysis, Barcelona, 15-18 July 1991 (Mohn, Bio-economics of mesh change in gadoid fisheries on the Scotian Shelf). The risk analysis mentioned with respect to Goal 4 also included results incorporating economic descriptions. Although this manuscript will be upgraded to a primary it will still not include all the information suggested by this goal and the appropriate primary was not completed.

5. Completion of age-structured transboundary fishery model for Georges Bank. The model may be of aid to transboundary issues (GOMAC) (cod, haddock, herring) and may warrant publication. (Mohn, Gavaris, Hunt, Stephenson)

This model did not progress during the review period because the necessary parameters were not made

available. This project will not continue in 1992.

6. Complete analysis of selectivity experiments using square and diamond mesh trawl nets conducted by Fisheries Development Division, FHMB. (Fanning)

Imposition of mesh size increases in the Regional groundfish fishery in March, and a revision of this decision in July, required numerous analyses of mesh selection effects to aid the decision making process. This, and resignation of the designated analyst (Fanning) in August, delayed completion of an overall analysis of available data. However, final selection curves have now been derived from all experimental and demonstration cruises and data interpretation and write-up is underway.

7. Analyze the quantities and size composition of by-catches of cod, haddock, and pollock in the foreign small mesh trawl fishery and assess the potential impacts of these on yields to the directed domestic fisheries for these species, updating and extending the analysis of this issue by Waldron and Sinclair in 1982. (Waldron, Showell)

Revised priorities during the year resulted in this project being deferred indefinitely.

8. Analyses of discards in the domestic cod, haddock and redfish fisheries on the Scotian shelf and report to CAFSAC. This project has been underway since 1987 and involves the incorporation of not only the biological results of discarding but a review of the regulations and the Industry directions which may have contributed to discarding. (Waldron, Showell, Bourbonnais, Wood)

Revised priorities during the year resulted in this project being deferred indefinitely.

9. Conduct experiment on the effects of the increase in trawl mesh size and mesh type (square vs diamond) in 1991-92 on fishing behaviour and resulting size compositions of the catches. This will require agreement to provide exemptions to mesh size increases for some commercial fishing vessels. (Showell, Waldron)
10. Retrospective analysis of VPAs. Initiate and complete a directed study into the 'retrospective problem' of VPAs, mainly through an investigation of model assumptions. The work would be based on simulation and sensitivity analysis and the results would be reported during 1991. (Mohn)

Analyzed two compartment model which duplicated pattern with simulated data and provides some foundation for goal 4 for 1992. Reported to CAFSAC Biological Reference Points Workshop a solution to the retrospective problem using the median of a bootstrapped distribution. (Mohn, Bootstrap estimates of ADAPT parameters and their projection in risk analysis).

It was ruled that DFO did not have the legal authority to grant exemptions from regulations under a circumstance where a commercial enterprise would obtain a financial benefit not available to non-exempt enterprises. It was, therefore, not possible to conduct this experiment.

#### 4. Additional Accomplishments:

1. Assessment methodology - VPA. Length-based population analysis. Invitation to, and participation at, ICCAT meeting in St. Andrews where a paper on the method was presented (Mohn, Length-based virtual population analysis, a review and swordfish example). (Mohn)
2. Assessment methodology - VPA. Presentation of working paper to CAFSAC on weighting in the tuning of VPA's. (Mohn)

#### 5. Goals/Expected Outputs for 1992:

1. Comparisons of North Atlantic fishery management regimes - a descriptive account will be completed. (Halliday)
2. Selection experiments using square and diamond mesh trawl nets - analysis will be completed and a report prepared. (Halliday)
3. The biological and economic feedback control model based on Scotian Shelf groundfishing is to be written up for the primary literature. (Mohn)
4. Analysis of the factors affecting fixed gear fishing success (See also Project No. 9769). (Fanning replacement)
5. Investigate and quantify changes in gear technology affecting commercial groundfish catch rates using IOP. (Showell)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

Comparisons of North Atlantic management regimes with A.T. Pinhorn, NWAPC, St. John's. Trawl mesh selection experiments with C. Cooper, Development, FMB, Halifax, and P. Fanning, ICOD. (Halliday).

##### ii. University Liaison -

Taught fisheries model module of Course Oceanography/Biology 4600/5600B at Dalhousie University. Served on Tara Marshall's doctoral thesis Review Committee, Dalhousie University. (Mohn)

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

Mohn, R. 1991. Stability and sustainability of harvesting strategies in a modelled fishery. NAFO Scientific Council Studies 16: 133-135 (Abstract).

iii. Scientific and Technical -

Kenchington, E., C. Têtu, and R. Mohn. 1991. Preliminary investigations of juvenile scallops (Placopecten magellanicus) in Nova Scotia inshore habitats. Can. Man. Rep. Fish. Aquat. Sci. 2123: 38p.

Mohn, R. 1991. Risk analysis of 4VsW cod. CAPSAC Res. Doc. 91/40: 21p.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

With the reorganization changes in MFD during 1991 and staff changes in Economics Branch, the future of the Fisheries System Group is uncertain. Notwithstanding this, progress has and is being made, and will be fostered during 1992/93. The research is considered to be highly relevant to the Division's mandate.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 112

Section: Southern Shelf

Project Title: National Sampling Program

Project Leader: Zwanenburg, K.

Other Researchers: Young, G.; Smith, W.; Fennel, J.; Donaldson, G.; Decker, T.; Lyon, D.

Work Activity: W.A.1.1.1.2

Key Words: commercial sampling; resource surveys; assessments; groundfish

1. Project Description:

A Scotia-Fundy data collection network, with technical staff located in Sydney, Halifax, Lunenburg, Lockeport, Yarmouth, and St. Andrews (N.B.), and coordinators in Halifax and St. Andrews, which collects biological information from all sectors of the fishing industry. Data are used as input to fish stock resource assessments and thus provide the basis of a rational management program. The program conducts research aimed at improving sampling methods, and collects biological data for various Division research programs.

2. Long-Term Objectives:

Continue sampling commercial groundfish landings, thereby providing reliable long-term information on the removals affected at age-by-area as an integral part of the groundfish and pelagic stock assessment process.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Produce the 1991 sampling schedule in consultation with divisional assessment personnel. Implement this plan as the priorities for sample collection in 1991. (Zwanenburg, Donaldson, Lyon, Decker, Smith, Fennel)

A comprehensive groundfish sampling schedule was developed early in 1991 in consultation with divisional assessment personnel. This established sampling priorities for all groundfish stocks and served as a guide to port technicians. The schedule is amended throughout the year, where necessitated by changes in the dynamics of the fisheries or the addition of ancillary data collection requests.

2. Port technicians will again be involved in the stock assessment process by meeting with assessment staff to discuss input data prior to the spring meeting. (Donaldson, Decker, Smith, Lyon, Fennel)

Port Technicians were consulted throughout the year by divisional assessment staff regarding development in regional fisheries. A number of meetings were held in which information relevant to the assessment process was discussed. This is a continuing indication of the changing role these individuals play in the assessment process.

3. Provide finalized 1990 sampling data to assessment personnel on electronic medium in time for the 1991 stock assessments. (Zwanenburg, Young)

Commercial sampling data was made available to assessment personnel in time for use in the 1991 stock assessment analyses. The data were provided in a verified and edited electronic data file structured for use as input to a number of divisional analysis software applications.

4. Establish quarterly ageing priority schedules to ensure coordinated data processing and timely commercial sampling data availability. (Zwanenburg, Young)

The protocol of ageing all commercial groundfish otoliths as they are received in St. Andrews was maintained throughout 1991. This was possible given the reduced volume of sampling relative to previous years resulting from reduced landings for many stocks. An inventory of all samples collected by species, stock, gear and date and the number of these which have been aged was provided to all assessment staff monthly.

5. Continue to act as scientific authority for maintenance of the newly developed ORACLE based CGS software. (Zwanenburg)

Acted as scientific authority to divisional computing staff when alterations or repairs to the CGS software were required.

#### 4. Additional Accomplishments:

1. Port Technicians undertook a public relations campaign to publicize the 1991 Fisheries Information Seminar held in SW Nova Scotia. This was achieved by one on one discussions with members of the fishing industry and the general public as well as through the distribution of posters. Port Technicians also participated in the Information seminar by introducing headquarters staff to the local public and by acting as a liaison between headquarters staff and the local public. (Donaldson, Lyon, Decker, Zwanenburg)
2. All port technicians participated in a pre-assessment meeting where preliminary results of all groundfish assessments were discussed and where their knowledge of local fisheries was used to aid in the interpretation of some of the input data. This process is indicative of the developing role of these positions within the division by an increased utilization of their knowledge of local fisheries operations into more non-traditional assessment approaches. (Zwanenburg)
3. Initiated the development of a National Sampling Program quarterly report. This report, presently for in-house distribution, lists landings (from quota reports for each species/stock) and total samples collected by major gear type. For each of these strata all information relevant to the development of the fisheries related by the port technicians are condensed and presented by week. The report is cumulative in that the final report will represent a complete record of observations on the fishery as recorded by the National Sampling Program.
4. Port Technicians introduced a number of headquarters staff to members of the fishing industry in southwest, eastern Nova Scotia and Cape Breton. This was done as the groundwork of a new initiative aimed at involving members of the industry with research projects developed and implemented in a consultative manner between industry and government. (Donaldson, Lyon, Fennell, Smith, Zwanenburg, Decker)
5. Terry Decker has written a user's manual for the developing distributed data entry network. The guide is being written from the perspective of a new user and in non-technical terms. (Decker, Charlton)
6. The exchange program initiated in 1988 between the Benthic Fisheries and Aquaculture and the Marine Fish Division will be continued this year. Gilbert Donaldson will provide assistance to the lobster tagging and lobster sampling program during times when groundfish landings are minimal. This time will be exchanged for person-time to be used in staffing MFD surveys. (Donaldson, Zwanenburg)
7. Sampling requests from other Atlantic Zone regions were honoured. Mackerel samples were collected as requested in the schedule submitted by the Quebec Region. (Donaldson, Lyon, Decker, Smith, Fennell, Zwanenburg)
8. Special sampling requests for the collection of scales and otoliths for age comparisons from Georges Bank haddock was carried out. (Donaldson, Lyon)
9. Arrangements were made with fishermen to bring ashore live cod from the Bras D'or Lakes. These fish were kept alive over an extended period. The fish were required in support of initiatives being undertaken at Dalhousie University under the auspices of the Ocean Production Enhancement Network (OPEN). (Fennell)
10. The area of operations of the Lunenburg Office was expanded to include both Sambro and east Jeddore as ports of landing to be sampled. A significant proportion of the inshore/midshore fixed gear landings of 4W cod and haddock come through these ports. (Decker, Zwanenburg)
11. Daryl Lyon is involved in a joint DFO/Industry project aimed at collecting temperature at gear information from both longline and otter trawl gear. Five different fishermen are involved in the Lockeport area. This project will continue through 1992. (Lyon)
12. Collaborated with Ralph Surette in writing an article on the role of port technicians in DFO. (Zwanenburg)

#### 5. Goals/Expected Outputs for 1992:

1. Produce the 1992 sampling schedule in consultation with divisional assessment personnel. Implement this plan as the priorities for sample collection in 1992. (Zwanenburg, Donaldson, Lyon, Decker, Smith, Fennell)
2. Continue to develop Port Technicians involvement in the stock assessment process by meeting with assessment staff to discuss input data prior to the spring meeting. Maintain present frequency of meetings with assessment staff. (Donaldson, Decker, Smith, Lyon, Fennell)
3. Provide finalized 1991 sampling data to assessment personnel on electronic medium in time for the 1992 stock assessments. (Zwanenburg, Young)
4. Establish quarterly ageing priority schedules to ensure coordinated data processing and timely commercial sampling data availability. (Zwanenburg, Young)
5. Continue to act as scientific authority for maintenance of the newly developed ORACLE based CGS software. (Zwanenburg, Charlton)
6. Complete the installation of remote data entry facilities for the Guysborough and Sydney offices. These were delayed as a result of operational constraint within the Division. (Charlton, Zwanenburg)
7. Initiate development of 'catch-at-age' output from CGS. (Charlton and Zwanenburg).

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Over the last three years, the National Sampling Program has evolved considerably, from primarily collecting samples to remote data entry, assisting scientists at fishermen's meetings, and so on. While these opportunities have always been there, staff are now taking advantage of it, to the benefit of everyone. During the coming year(s) the challenge will be to appropriately define the sampling roles of NSP and IOP. The NSP is one of the Division's most valuable resources and will continue to be so into the future.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 113

Section: Central Shelf

Project Title: International Observer Program

Project Leader: Waldron, D.

Other Researchers: Showell, M.

Work Activity: W.A.1.1.1.2

Key Words: commercial sampling; resource surveys; assessments; groundfish

1. Project Description:

Joint management of IOP with Fisheries & Habitat Management Branch. Design and implementation of a data collection program. Ensure the quality, editing, storage, and analysis of fisheries data from the Scotia-Fundy IOP. The program provides data and analyses for fisheries research and management studies in supporting the development of foreign and domestic fishing plans.

2. Long-Term Objectives:

Continue joint management of the IOP, maintain and analyze the IOP data base in support of fisheries management research, assessments, industry development and operational activities of DFO in the Scotia-Fundy Region, and to other DFO regions when necessary.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Manage the Science responsibilities under the IOP. Particular attention will be directed towards increased coverage of groundfish vessels <65', required as a result of the Haché Task Force recommendations. (Waldron, Showell)

Sampling requirements were determined through interviews and consensus with MFD and other Departmental scientists. A sampling schedule was developed on a fishery basis and presented to the observer contractor for collection by the corps. To ensure sampling requirements were met, the completion of the schedule was closely monitored through liaison with the contractor. Where necessary, the schedule was modified to meet required sampling and coverage levels. Data returned by the observers were transferred to electronic medium, edited, and loaded to the MAROD data base. Generally, data were available within two weeks of the end of the observer's trip until August 1/91 when processing was halted due to funding limitations.

Data and/or data summaries were provided to MFD and Departmental scientists for inclusion in the assessment process.

Data and/or summary reports from the IOP were supplied to numerous other agencies. These include 1991 longline tuna data submitted to ICCAT, sampling summaries delivered to NAFO and Regional Directors of Science for distribution, and information supplied to regional and national DFO representatives for use in the bilateral process. In addition, catch rate data were presented to International Directorate for the assignment of effort limits for all foreign fisheries in the Atlantic Zone. Data and summary reports were distributed to Senior Advisor for Foreign Fisheries, Director of Conservation and Protection and RDG related to domestic and foreign fisheries.

The IOP collected and performed preliminary analysis on data from developmental fisheries on the Scotian Shelf; 3-6 mackerel (Poland, Bulgaria and USSR), Illex (Japanese squid jigger fleet), Scotian Shelf porbeagle shark (Faroese and Clearwater).

2. Ensure an acceptable standard of accuracy and validity of data collected by observers, establishing training requirements for biological observations, administering of final certification examinations and at sea inspections. Methods of obtaining feedback from industry on observer performance to address credibility issues will be examined. (Waldron, Showell)

There were 4 training sessions and certification exams administered this past year. Where possible, the Observers were taken to sea aboard an R/V or commercial vessel in the presence of DFO personnel (Showell for MFD and Grace for FHMB). These trips were often augmented with trips by Contractor personnel who were debriefed by DFO personnel. Several at-sea inspections by uniformed officers were reviewed by FHMB and MFD personnel. Feedback from the industry through informal 'one-on-one' discussions (Waldron and Showell) and port technicians conveying information were used this year. An attempt by MFD to interact with NSP on this issue never materialized. The data base conversion prevented the normal extensive reviews of the data during 1991.

3. Complete conversion of observer data base from S2K to ORACLE and provide analysis views which resemble those from the research vessel data base to improve new access. Support of the new ORACLE data base will be done by MFD/BIO CS section. Through consultation with users throughout

the Atlantic Zone, define modifications/enhancements to the data base/editor. After a firm plan has been devised, minor and urgent enhancements will be done by MFD/BIO CS staff. (Waldron, Showell, Branton, Charlton)

The conversion task was greater than anticipated, and it was completed with deficiencies in several items which hamper data utilization. These items include the ability to capture large pelagic longline data, designation of directed species by set, and the set duration. The editor is not complete and the integrity of certain fields such as Unit Area cannot be checked. These should be incorporated by the CS section over the next review period. Modifications and enhancements will be developed in consultation with users in the Atlantic Zone next year.

4. Conduct consultations with MFD staff to inform about the nature of the present IOP and solicit feedback which will provide guidance on future directions for the project. (Showell, Waldron)

Group and individual consultations were conducted. Modifications to data collection methods and training were initiated based on these consultations (e.g. tuna, swordfish and mackerel data collection procedures were modified). Additional information collection on each trip was instituted (e.g. vessel and Observer specifications). This consultative approach proved successful and will be continued next year.

5. Complete the analysis comparing port sampling and IOP length frequency samples for regional groundfish stocks, and present the results to CAFSAC. (Showell, Waldron)

Due to the unanticipated delays and complexity of the IOP data base conversion, this project was not completed. It may be resumed depending upon the results of the NSP/IOP Divisional Review (See 5.7).

#### 4. Additional Accomplishments:

1. Participated in several ad hoc meetings to develop a Zonal O.P. Automated Trip Report Package. This set of data will be of use in the interpretation of the Observer trips at sea. (Showell)
2. Participated in a National O.P. Working Group to develop data handling at sea. The project is deferred until item #1 above is complete. (Showell, Waldron)
3. The second year of the 4X/5Z small dragger fishery deployments was a success. More structure was instituted in the deployment of Observers. Also the shifting of the herring 'over the side sales' project from the O.P. to industry freed resources to be used in the small dragger program. A report is in progress. (Waldron)

#### 5. Goals/Expected Outputs for 1992:

1. Develop, through consultation with MFD and other clients, and monitor a sampling plan for 1992/93. Included in this plan are assessment, research and fisheries management samples. (Showell)
2. Monitor Observers Contractors performance against contract. (Showell)
3. Set work loads, priorities, data flow schedules, and monitor data entry and data editing contracts. Also liaise with Computer Section on completion of modification to data base. (Showell)
4. Participate in Observer training and certification, including one R/V training cruise. (Showell)
5. Liaison with FHMB, to develop policies and direction for O.P. using newly-created MFD-FHMB management committee. (Waldron)
6. Participate in National Planning Group for O.P. (Waldron, Showell)
7. Define roles, and coordinate activities of OP with NSP through participation in Divisional W.G. created in 1991. (Showell)
8. Provide information to industry, ICCAT, NAFO, and other Regions where access to the ORACLE data base is not practical. (Showell, Waldron)
9. Enhance new observer contract by incorporating improved data entry, data capture and reporting structures and sit on DFO-SSC contract evaluation committee. (Waldron)

#### 6. Background:

##### Highlights:

1. The Haché Task Force set the following coverage levels for the greater than 100' fishing vessels: in 1990, 25%; for 1991, 50%; and by 1993, 100% coverage. Currently the foreign fleets are observed at 100%. Science and Operations resource requirements were submitted as a joint submission for consideration under AFAP. Science's resource requirements were ignored with all the resources going to FHMB. Again in 1991, this situation aggravated the work-load problem and should be addressed for the next review period. (Waldron)
2. Funding permitted a deployment schedule of nearly 40% for vessels greater than 100' on the Scotian Shelf. Vessels between 44'-65' had seasonal coverage of 10-15% over the area Georges Bank to Sable Island Bank. These deployments are expensive (= \$600/day) because of high travel cost and extra land days. The program operations were streamlined to improve capture of more data. These included forms for entry of new ship data, creation of catch effort and length frequency views. As with last year's PREP, concern is expressed about the low level of PY

support for the program. Every effort has been made to improve data entry, editing and access but monitoring of the contract performance and credibility of the Observers are still below expectations. (Waldron)

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

Data handling and data editing contracts for Observer data (Showell, Waldron); Main Observer Contract in conjunction with FHMB, Scientific Authority (Waldron).

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The EDP conversion did encounter some difficulties but these were primarily due to the short time available and the complexities of the problem. These are and will be resolved in 1992. Overall, while IOP is becoming more useful to MFD, more needs to be done to explicitly define sampling requirements and input information into the standard assessments. These should be the priority work areas in 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1140

Section: Gulf of Maine

Project Title: Groundfish Trawl Surveys

Project Leader: Hunt, J.

Other Researchers: Brown, L.; Strong, M.; Gavaris, S.; Perry, I.; Gale, J. ; Koeller, P.

Work Activity: W.A.1.1.1.2

Key Words: resource surveys; assessments; groundfish

1. Project Description:

Conduct random stratified surveys on the Scotian Shelf, Georges Bank, and in the Bay of Fundy using standardized bottom trawl gear for direct input into assessments and provide support for other surveys designed to address specific research questions conducted at various times by the Division. Conduct research on survey methodology and design.

2. Long-Term Objectives:

Provide information on the abundance, distribution, and biology of major groundfish species from standard cruises and meet immediate needs of special research cruises. Improve survey methodology and design to provide more accurate and precise abundance estimates for the assessment of groundfish species.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Organize and conduct: (a) summer groundfish survey on the Scotian Shelf; and (b) spring survey of cod and haddock on Georges Bank. (Hunt, Strong)

Materials, charts and programs were prepared for these surveys. Cruise supply inventory was maintained. Note that the summer survey in 4VsW was completed with the Lady Hammond because of Needler breakdown.

2. Code and edit standard (July Scotian Shelf and March Georges Bank) groundfish surveys. (Strong, Brown, Nelson)

Results from standard surveys were coded, edited and added to the data base. Upgrades in both the VMS and Oracle software resulted in some delays requiring programming changes.

3. Assist in the organization, outfitting and conduct, data coding and editing of one or more additional Division surveys. (Strong, Brown)

The March 4VsW survey was added as a standard survey.

4. Continue deployment of SCANMAR on standard surveys and maintain data base of results. (Strong)

SCANMAR was deployed on standard surveys and data base updated.

5. Develop and implement a station selection software for application to the Scotian Shelf. (Gavaris, Gale)

Station selection software was completed with an interface to the mapping system.

6. Implement protocol for standard trawl mensuration. (Strong)

Standard protocol for trawl mensuration, including training, is now in place.

7. Revision of survey trawl manual to reflect changes to protocol. (Strong, Hunt)

Revision of survey manual is in draft form.

8. Complete revisions and document the new groundfish survey edit system. (Gale)

Groundfish survey edit system is documented in draft form and will be appended to survey manual.

9. Organize survey trawl mensuration workshop in conjunction with Newfoundland Region and Headquarters. (Koeller)

Trawl survey workshop was organized and Scotia-Fundy trawl mensuration results were presented. (Strong, Koeller)

#### 4. Additional Accomplishments:

1. Trawl course was completed by MFD personnel. Most staff with continuing sea duty have completed the course as well as four crew from the Needler.
2. Marine Emergency Duties course was completed by most sea-going staff.
3. Published analysis of trawl mensuration data collected during standard groundfish surveys. (Koeller)

#### 5. Goals/Expected Outputs for 1992:

1. Organize and conduct: (a) summer groundfish survey on the Scotian Shelf; and (b) spring survey of cod and haddock on Georges Bank. (Hunt, Strong)
2. Code and edit standard (July Scotian Shelf and March Georges Bank) groundfish surveys. (Strong, Brown, Nelson)
3. Continue deployment of SCANMAR on standard surveys and maintain data base of results. (Strong)
4. Complete revision and publication of survey manual. (Strong, Gale)
5. Provide training for use of edit system, SCANMAR, preparation and outfitting of surveys for BIO personnel as required. (Strong, Brown)
6. Publish results of SCANMAR data analysis. (Strong)
7. Participate in the analysis and review of fixed versus random stations for bottom trawl survey designs at ICES Workshop in Woods Hole. (Gavaris, Hunt)
8. Participate in Trawl Working Group. (Strong)
9. Summarize trawl parameters from tows during a standard bottom trawl survey. (Strong)

#### 6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

#### 7. Publications:

- i. Primary -  
Koeller, P. 1991. Approaches to improving groundfish survey abundance estimates by controlling the variability of survey gear geometry and performance. J. Northw. Atl. Fish. Sci., Vol II, p. 51-58.
- ii. Interpretive Scientific -
- iii. Scientific and Technical -  
Walsh, S., Koeller, P.A., D. McKone. 1991. Report on the Trawl Mensuration Workshop, St. John's, Newfoundland, March 18-19, 1991. Working Paper presented by P. Koeller to the ICES PTFB Working Group meeting, Ancona, Italy, April 1991.
- iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

Program is making good progress, particularly in gear mensuration project. During 1992, support for the 4VsW March survey will be transferred to BIO.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1150

Section: Various

Project Title: Groundfish Age Determination

Project Leader: Hunt, J.; Annand, C.

Other Researchers: Brown, L.; Strong, M.; Robicheau, R.; Nelson, C.; Sampson, H.; Perley, P.; Buzeta, M.; Van Eeckhaute, L.; Beanlands, D.; Simon, J.; Dale, C.; Young, G.; Hamel, J.; Bourbonnais, C.; MacEachern, W.

Work Activity: W.A.1.1.1.2

Key Words: assessments; groundfish; age determination

1. Project Description:

Age determination of groundfish through interpretation of otoliths or other structures, and research on validation methodology and growth.

2. Long-Term Objectives:

Provide accurate estimates of age composition for use in stock assessments and other biological studies.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Carry out age determination of survey and commercial catch samples for cod, haddock and pollock. (Robicheau, Hunt, Sampson, Nelson, Brown, Perley, Buzeta, Van Eeckhaute)

All required age determination of cod (7700), haddock (6500) and pollock (4000) survey and commercial samples was completed within established guidelines for precision and deadlines.

2. Continue to monitor precision of age determinations for all readers and report results. Provide training as required. (Robicheau)

Two intra-reader comparisons were completed with an indicated precision of 70-90%. Results were compiled and distributed. Note that senior age reader retired in June 1990.

3. Continue to conduct exchanges with U.S.A. age readers for cod, pollock and haddock. (Robicheau, Sampson, Buzeta, Van Eeckhaute)

Exchanges were completed for cod and haddock. A four-day workshop with U.S.A. researcher was held in St. Andrews during September. A detailed report summarizing results was prepared for distribution.

4. Continue participation in silver hake validation with U.S.S.R., complete age determination of 1990 samples and provide training if required. Joint publication of revised guideline for age determination may be possible. (Hunt)

Ageing of silver hake was completed. No further requirement for age determination guidelines was identified.

5. To provide age determinations for a radio isotope validation study of silver hake and assist in publication of results. (Hunt)

Ageing of silver hake for use in a radio isotope study was completed. No further progress on analysis of results pending age determination by U.S.S.R.

6. Prepare a video tape recording of species and stock-specific cod, haddock, pollock and silver hake otolith types, including interpretation and audio comments, for training and reference. (Hunt, Robicheau)

Substantial numbers of annotated video tape images were prepared to document results of workshop and species-specific characteristics for cod and haddock.

7. Investigate use of image analysis hardware and software for potential development of a computer based verification technique. Cod in 5Zj,m will be the target species for trial studies. (Hunt, Buzeta)

Progress limited to development of reference collection noted above as goal #6.

8. Publish results of CAFSAC ageing methodologies working group. (Hunt)

Results published as CAFSAC Res. Doc. 91/63

9. Investigate alternative methods for sample prioritization. (Hunt, Charlton)

Two approaches were used to assess potential for improving the precision of catch at age for Georges Bank cod. No significant difference in probability of age at length between fixed and mobile gears was found suggesting that keys could be combined with a resulting reduction in CV's for catch at age. Subsampling of combined samples (10 fish per 3 cm) reduced number of ages by about 30% with no significant difference in proportion at age and length or catch at age.

10. Assess feasibility of re-ageing pre-1985 haddock commercial samples to improve estimates of catch at age. (Van Eeckhaute)

No progress due to time constraints.

4. Additional Accomplishments:

1. Preliminary results of a study to assess occurrence of 'settling checks', its characteristics, and its differences from the first annuli, was presented to PREP 1991. (Hunt)
2. Re-analysis of 21 samples from 1985 SZ cod otoliths was done to estimate occurrence of settling checks, and its impact on ageing of these samples. (Hunt)

5. Goals/Expected Outputs for 1992:

1. Carry out age determination of survey and commercial catch samples for cod, haddock and pollock. (Hunt, Sampson, Nelson, Brown, Perley, Buzeta, Van Eeckhaute)
2. Continue to monitor precision of age determinations for all readers and report results. Provide training as required. (Hunt)
3. Continue to conduct exchanges with U.S.A. age readers for cod, pollock and haddock. (Hunt, Buzeta, Sampson, Van Eeckhaute)
4. Provide training and documentation for use in developing age reader experience at BIO and facilitate transfer of ageing duties. (Hunt)
5. Assist in the analysis and publication of silver hake age validation study. (Hunt)
6. Continue development of video image library for age determination. (Hunt, plus age readers)
7. Investigate potential application of stock specific otolith characteristics in order to improve and standardize age determinations. (Hunt plus other age readers)
8. Assess the feasibility of re-ageing pre-1985 haddock commercial samples to improve estimates of catch at age. (Van Eeckhaute)
9. Completion and publication of MFD age determination manual. (Hunt)
10. Determine the budget requirements and the PY utilization to set up lab facilities at BIO for Ageing Groundfish stocks on a routine basis. (Annand, Hunt)
11. Initiate training for inexperienced BIO age readers. (Annand, Hunt)
12. Set up ageing lab facilities at BIO including the investigation of more advanced methodologies used in other ageing facilities around the world. (Annand)
13. Determine the schedule of transfer of ageing responsibilities from St Andrews to BIO. (Annand)
14. Undertake a study of SZ cod otoliths to assess characteristics such as settling checks, interannual differences in growth increments, and comparisons of these with adjacent stock. (Hunt)

6. Background:

Highlights:

Retirement of senior age reader (Robicheau) resulted in reassignment of ageing duties. Precision of ageing was acceptable for all species/stocks. Anticipated requirement for training in 1992 will increase the workload for age readers.

Selected Involvements:

i. Collaborative Research -

Provided species identification from otoliths in support of Marine Mammals Project. (Hunt, Bowen)  
Initiated development of otolith atlas. (Hunt, Campana) Provided reviews of two technical and three primary publications. (Hunt)

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

Scientific authority for winter flounder ageing contract. (Hunt, Vandermeulen)

v. Other -

7. Publications:

i. Primary -

Hunt, J.J. 1992. Morphological characteristics of otoliths for selected fish in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. (in press)

ii. Interpretive Scientific -

iii. Scientific and Technical -

Neilson, J.D., M-I. Buzeta, and J.J. Hunt. 1991. Comparison of catch at age matrices employed by Canada and the U.S.A. in assessments of stock status of Atlantic cod in 5Z. CAFSAC Res. Doc. 91/51.

Hunt, J.J. 1991. Report of the Ageing Methodologies Working Group. CAFSAC Res. Doc. 91/63.

Hunt, J.J., M-I. Buzeta, L. Van Eeckhaute, and N. Munroe. 1991. Report of the September 1991 ageing workshop.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Activity on this project has been good, particularly with introduction of Image Analysis System. During 1992, a number of stock assignments will be transferred to BIO. This will have to be done carefully to ensure continuity in the ageing.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 117

Section: Southern Shelf

Project Title: Fisheries Recruitment Variability

Project Leader: Frank, K.

Other Researchers: McRuer, J. ; Hurley, P.

Work Activity: W.A.1.1.1.7

Key Words: ichthyoplankton; larvae; recruitment; juvenile surveys; capelin; cod;  
fisheries ecology1. Project Description:

The research involves site-specific, mechanism-oriented studies that determine ecological factors responsible for changes in year-class strength of commercially important marine fish stocks. Research efforts have focused on the Scotian Shelf (cod and haddock), and on the Grand Banks (capelin).

2. Long-Term Objectives:

New approaches to predicting year class strength are explored, particularly those which focus on the unique characteristics of the survivors to provide insight into recruitment mechanisms. This includes both meristic and morphometric variation as well as field and laboratory experiments. The Eastern Shelf Program and OPEN provide major opportunities for expression of these research approaches in the next 3-5 years.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Participate in a joint BSB/PCSB/OPEN research initiative to map the biological variability, particularly in egg and larval cod distributions, in association with drifting buoys and a current meter array on Western Bank. Cruise time requested aboard CSS Dawson in April/May. This is an ESP/MFD objective. (Frank with K. Drinkwater - PCSB, K. Thompson - Dalhousie, B. Sanderson - MUN)

Objective achieved as planned. CCS Dawson cruise #91-03 was successful in meeting survey objectives in addition to sampling shelf water entrained by an offshore eddy. Sample analysis is underway.

2. Conduct an analysis of the SSIP data base (1979-81) to a) define the timing and location of cod and haddock spawning on the Scotian Shelf, and b) define the scales of variability in the egg, larval and pelagic juvenile distribution of these two species. This is an ESP/MFD objective. (Frank and Zwanenburg)

Objective achieved as planned. This information has been instrumental in guiding OPEN's physical and biological sampling protocol on Western/Sable Island Bank. If time permits, further analysis, interpretation and eventual publication is planned.

3. Using fish from the February Georges Bank survey and the July survey in 4X estimate the mean vertebral count for each age group of haddock collected during the survey in order to test the hypothesis that vertebral count covaries with year class size. (Frank)

Haddock were collected during the February and July surveys aboard RV Alfred Needler (cruise #91-148, 91-154). Fish that were sampled in detail onboard have been subsequently aged and a methodology for vertebral count evaluation has been determined. X-radiographic techniques will be used to count vertebrae on a Phillips industrial x-ray system with image analyses available at BIO in AGC (EMR) that is normally used to identify sedimentary structures in cores.

4. Complete analysis of larval sand lance data from SSIP and prepare manuscript for publication. (Hurley)

Analysis continuing, but manuscript not complete.

5. If hardware is available, a) process audio tapes of CTD data collected during vertical distribution studies associated with FEP, and b) begin analysis of gadoid egg and larval depth distribution. (Hurley)

Hardware not available. No progress.

6. Continue to serve as Ph.D. supervisor for P. Ouellet in Department of Oceanography at Dalhousie University. (Frank)

Thesis supervision continuing on topic of survival potential and trophic related processes in shrimp larvae in the Gulf of St. Lawrence. Anticipated completion date is June 1992.

7. Continue to analyze data associated with the southeast Shoal capelin project and prepare a manuscript for publication on drift modelling of larval capelin. (Frank with Loder, Carscadden and Leggett)

Analysis continuing with one manuscript accepted for publication in CJFAS entitled "Larval flatfish distributions and drift on the Southern Grand Bank". (Frank with Loder, Carscadden, Leggett, Taggart)

8. Participate in OPEN through collaboration with recruitment project leaders and associated staff. (Frank)

Participation highlights have included involvement in two weekend meetings of the complete network at Old Orchard Inn, Wolfville, N.S., in March and November, and of the recruitment group at Dalhousie in August. Research associates, PDFs and students affiliated with OPEN have greatly benefited from their interaction with MFD field and local staff, and it can be said that this interaction has contributed significantly to the conduct of their (OPEN's) research.

9. Test the predictive power of the capelin recruitment model published in 1984 (CJFAS 41: 1193) with eight additional years of recruitment data (1980-87). (Frank with Carscadden and Leggett)

There have been no opportunities within this calendar year to investigate this important objective.

10. Maintain linkages with national and international climate research and recruitment initiatives. (Frank)

This objective has been met by a) appointment as chairman of a DFO Working Group on Cod and Climate Changes that is linked to GLOBEC and will ultimately contribute to the ICES Cod and Climate Change Program, and b) appointment as a member of the ICES Steering Group on Cod and Climate Change. Presentations were made to the Symposium on the Climate of Nova Scotia, the GLOBEC Implementation Team Meeting at MIT and Shaw Cable's (Channel 10) science program.

#### 4. Additional Accomplishments:

Manuscript on timing of cod spawning on the Scotian Shelf revised and accepted for publication in 1992 issue of CJFAS. (Hurley with Brander)

#### 5. Goals/Expected Outputs for 1992:

1. Participate in a joint BSB/PCSB cruise to Western/Sable Island Bank in November aboard CSS Dawson (or replacement) to obtain estimates of cod larval growth, condition and dispersion from repetitive sampling of a patch of cod larvae. This is an ESP project linked to OPEN. (Frank and McRuer with Drinkwater, Thompson - Dal., Sanderson - MUN)
2. Serve as chairperson and fulfil the 6 terms of reference of the DFO Cod and Climate Change Working Group which reports to B. Muir. The Committee (8 members from DFO and university labs) has met once, worked by correspondence since August and will convene again early in 1992. Completion of the terms of reference is expected near the end of 1992 for presentation to B. Muir and the Symposium on Climate Change and Northern Fish Populations in Victoria, B.C. (Frank)
3. As the Canadian member, contribute to fulfilling the terms of reference associated with the ICES Steering Group on Cod and Climate Change, with B. Rothschild, University of Maryland as Chairman of the Committee. (Frank)
4. Continue thesis supervision of P. Ouellet, Department of Oceanography, Dalhousie University. (Frank)
5. Submit a manuscript for publication in CJFAS based on the J.C. Stevenson Memorial Lecture presented to the 1992 CCFR. (Frank)
6. Continue generation and analysis of vertebral count data from Georges and Browns Bank haddock to test the hypothesis that vertebral count covaries with year class strength. (Frank)
7. Continue involvement in OPEN through collaboration with recruitment project leaders and associated staff. (Frank)
8. Complete analysis of larval sand lance data from SSIP and prepare manuscript for publication. (Hurley with Stone).
9. Conduct qualitative analysis of FEP gadoid egg and larval depth distribution, if time permits. (Hurley)

#### 6. Background:

Highlights:

Received invitation to present J.C. Stevenson Memorial Lecture at the 1992 CCFR. (Frank)

Selected Involvements:

##### 1. Collaborative Research -

K. Drinkwater and J. Loder (PCSB) (Frank); J. Carscadden (DFO, St. John's) (Frank); Several university based OPEN investigators including C. Taggart and K. Thompson (Dalhousie), W.C. Leggett

(McGill), B. Sanderson (MUN) (Frank); H. Stone (FAFO) (Hurley); B. Topliss (PCSB), K. Brander (Lowestoft) (Hurley).

ii. University Liaison -

Ph.D. supervisor for P. Ouellet (Frank); OPEN project investigators (Frank).

iii. Communications -

TV interview on Greenhouse Effect and Canadian Atlantic fishery. (Frank)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Frank, K.T. 1991. Predicting recruitment variation from year class specific vertebra counts: An analysis of the potential and a plan for verification. *Can. J. Fish. Aquat. Sci.* 48: 1350-1357.

Paine, M.D., W.C. Leggett, J.K. McRuer, and K.T. Frank. 1991. Effects of incubation in oiled sediment on emergence of capelin (Mallotus villosus) larvae. *Can. J. Fish. Aquat. Sci.* 48: 2228-2239.

Topliss, B.M., L.A. Payzant, P.C.F. Hurley, J.R. Miller and J. Freemantle. 1991. Interpretation of multi-season, multi-year colour imagery for a continental shelf region. *Oceanologica Acta* 14: 533-547.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The first field season of the OPEN initiative on the Scotian Shelf was 1991. Thus far the progress appears to be going as planned. The addition of haddock and capelin work indicate the breath of study that this project has undertaken and points to the value of a multi-species approach in the study of recruitment processes.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 118

Section: Southern Shelf

Project Title: Otolith Studies

Project Leader: Campana, S.

Other Researchers: Hamel, J.

Work Activity: W.A.1.1.1.2

Key Words: otolith ; ageing ; recruitment ; assessment research ; cod ; fisheries  
ecology1. Project Description:

Study of population dynamics through otolith-based techniques. Ongoing studies include the determination of cod stock structure, juvenile cod recruitment to the inshore region, and the analysis of the relationship between year-class strength and early life history growth rate. Age determination techniques at both the daily and yearly level are being improved through research on otolith growth.

2. Long-Term Objectives:

Improve our knowledge of population dynamics through use of otolith-based techniques. New applications will be generated through research on the basic processes affecting otolith growth, particularly at the microstructural level.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete manuscript based on the results of the international otolith microstructure calibration study. Submit for primary publication. (Campana with Moksness)

The manuscript was completed, submitted, and accepted for publication in the ICES J. Mar. Sci. The paper documents the first realistic estimates of accuracy and precision for age determinations based on otolith microstructure.

2. Revise second chapter of the multi-authored volume on otolith microstructure techniques. Submit both chapters for primary publication. (Campana with Jones)

The chapter was revised as planned. Both chapters are now in the hands of one of the editors, and are in the final stages of editing.

3. Convene ICES-requested workshop on otolith microstructure techniques. In its report to the Recruitment Processes Working Group, the workshop convenors will cite specific recommendations concerning both technical matters and approaches to collaborative studies. (Campana with Moksness)

The workshop was held in Arendal, Norway, chaired by Campana, and attended by 22 scientists representing 12 countries. In addition to discussing technical recommendations, the workshop prepared a detailed protocol for collaborative studies involving otoliths, reviewed the limitations of the most common applications, and assessed sources of variability as they affect precision. A report was prepared and submitted to the ICES Recruitment Processes Working Group.

4. Continue radiochemical age validation of silver hake. All radiochemical assays will be completed, as will the Canadian ageing (via annulus counts). The Soviet annulus counts will be initiated. (Campana, Hunt, J. Smith, Waldron)

The radiochemical assays of the cores were completed, and although accurate, produced signals which were only slightly above background. Since the Th-228/Ra-228 isotope pair has never before been used to age vertebrates, it is not surprising that some technical refinements were required. Accordingly, the plated samples were sent to some colleagues in France, who operate one of the most sensitive radioactive dating facilities in the world. We are still awaiting the assay results from that lab. In the interim, the matching otolith from each core has been aged by J. Hunt, and has been sent to the USSR for their age interpretation.

5. As Program Chairman, prepare for the Canadian Conference for Fisheries Research (CCFFR) in January 1992. (Campana)

Theme session convenors were appointed, advertisements and notices distributed, and the scientific program prepared. The final program has now been distributed; on the basis of the number of papers/posters being presented, the 1992 CCFFR will be one of the largest in recent years.

6. As Co-Chairman for the international symposium, "New Directions in Otolith Research and Application," continue symposium planning, direct Steering Committee, prepare and issue Call for Papers, and prepare publication outlet. (Campana with Dean)

Symposium preparations are well underway. Symposium announcements were published in CJFAS, Mar. Ecol. Prog. Ser., AFS Fisheries, and a variety of fisheries newsletters. A Call for Papers was printed and distributed to 1500 fisheries professionals and institutions around the world. Applications for external funding have been submitted to various agencies. The conference facilities have been booked, and a book publisher confirmed. Initial reaction to the symposium from the scientific community has been very positive.

7. Continue analysis of data relating yearclass strength to early life history growth. Estimates of yearclass strength will be derived from VPA while early life history sizes and growth rates will be backcalculated from the sequence of daily increment widths in the otoliths. (Campana, Neilson)

Funds were not provided in the last fiscal year to support the analysis, which will require skills not available in the Division.

8. Serve as consulting scientist for the Age and Growth Subproject of the Eastern Caribbean Flyingfish Project. The direction of the project and the quality of age determination procedures being conducted in Barbados will be monitored, and if necessary, modified. Radiochemical age determination techniques will be explored. (Campana, with Hunte, Oxenford, Deane)

The otolith-based age determinations, mark-recapture, and migration studies have largely been completed. Adult flyingfish otoliths were cored and prepared for radiochemical assay. The initial results from the radiochemical dating indicate that the adults are one year old. However, as was the case with the silver hake otoliths (see #4 above), the signal:noise ratio was low. The refinements to the radiochemical procedure being implemented for the silver hake otoliths will also be applied to the flyingfish.

9. Coordinate invited seminar series, "Fisheries Oceanography," for the Biological Sciences Branch. (Campana)

Speakers were invited, notices distributed, and all arrangements made for the seminar series. The list of 8 speakers was international in scope, and the talks were well attended.

10. Complete statistical analysis of otolith shape data in support of cod stock structure study. A manuscript will be initiated. (Campana with Casselman)

The statistical analysis was completed and a manuscript initiated. The shape of each one of the three cod otoliths varied significantly with sex, age, and stock affinity, even after a length effect was removed. Discriminant functions can be used to classify unknown samples (collected in a different year) as to stock with a moderate level of success. However, most fish could be classified as to broad region of capture with a high probability of success (up to 95%). The implication of these results is that the approximate origin of an individual cod can be determined based only on otolith shape, and in the absence of any information on sex, age or fish length.

11. Maintain image analysis system for continued use with otolith preparations, as well as for Divisional and Branch requests. (Campana)

The image analysis system was used in research by graduate students and scientists from Marine Fish Division, Biological Oceanography Division, Benthic Fisheries and Aquaculture Division, and Dalhousie University, and was demonstrated to a variety of visiting scientists from inside and outside Canada, as well as at BIO Open House. The system is heavily used, and although effective for the purposes for which it was designed, is now seriously outdated; neither the framegrabber nor the software is supported any more by the manufacturer. The system desperately needs an upgrade, which with current technology, would make it more flexible, easier to use, and available for use by more MFD staff.

#### 4. Additional Accomplishments:

1. Appointed co-editor of multi-authored volume on otolith microstructure techniques. All 7 of the chapters have now been scientifically edited, and are now in the hands of the technical editor. The volume is expected to be published as a Special Publication of CJFAS in 1992. (Campana)
2. Started joint venture with Virginia Marine Resources Commission to apply radiochemical dating procedure (Campana et al. 1990) to black drum (an east coast fish species). The black drum have now all been aged, otolith cores extracted, and cores prepared for radiochemical assay. (Campana)
3. Invited to the main research labs of Perkin-Elmer (Connecticut) and provided with \$5K worth of consulting and equipment time on state-of-the-art laser-based elemental analysis machine. The intent was to determine if elemental fingerprinting of otoliths is possible with the new technology. It indeed proved to be possible, suggesting that it may be possible to determine spawning sites and retroactively determine migration paths through elemental analysis of otoliths. (Campana)
4. Invited to workshops on: a) age determination of Sebastes (USSR), b) juvenile northern cod (Nfld), and c) microchemistry of otoliths (Australia). (Campana)
5. Asked to review \$2773K in grants for NSF (6), MARFIN, and the DFO Subvention program, as well as 2 Ph.D. theses and 27 manuscripts for a variety of scientific journals (eg- CJFAS, CJZ, JNWFS, NAJFM, Antart. Sci., Cell Tiss. Res., Mar. Biol., Fish. Bull., Aquat. Living Res., J. Fish Biol., Copeia, Aust. J. Mar. FW. Res., and JEMBE). Also asked to serve on NSF grant review panel (declined). (Campana)

6. Taught a graduate course on age determination of fishes at Dalhousie University, and lectured in a 3rd year fish biology course. Gave lay presentations to junior high and high schools. At BIO, gave presentations on otoliths and demonstrations of image analysis to 35 Cubs, 10 reporters, 2 groups of 25 Grade 6 students, the Marconi Foundation (Italy), 20 ICOD representatives, and the Minister of Fisheries. (Campana)
  7. Consulted for advice on otoliths, age determination, and/or image analysis by scientists and graduate students from USSR, Iceland, New Zealand, Australia, Malawi, Chile, South Africa, France, Calif., Rhode Island, Colorado, Minnesota, B.C., Ont., Que., and the Maritimes. (Campana)
  8. Prepared otolith fact sheet for Communications; BIO Weekly Briefing on otolith shape and stock structure. (Campana)
5. Goals/Expected Outputs for 1992:
1. Complete editing of multi-authored volume on otolith microstructure techniques, and submit for publishing as Special Publication of CJFAS. (Campana, Stevenson)
  2. Prepare manuscript on stock identification of cod in the NW Atlantic through otolith shape analysis. (Campana, Casselman)
  3. Complete radiochemical age validation of silver hake, as well as the Soviet annulus counts. (Campana, Hunt, J. Smith, Waldron)
  4. As Program Chairman, prepare for and convene the Canadian Conference for Fisheries Research (CCFFR) in Jan 1992. (Campana)
  5. As Co-Chairman for the international symposium, "New Directions in Otolith Research and Application", continue symposium planning, direct Steering Committee, and prepare program. (Campana, Dean)
  6. Present ICES Otolith Microstructure Workshop report to ICES Recruitment Processes Working Group (who had originally requested that the workshop be held). Contribute to remainder of Working Group agenda items, much of which is otolith-oriented. (Campana)
  7. Complete radiochemical dating of black drum. (Campana, J. Smith, Jones)
  8. In light of the departmental priority given to the 4Vs/4T cod differentiation problem, contribute to a collaborative resolution of the problem through expansion and application of the otolith shape analysis project results (see 3.10). Otolith shape has been demonstrated to be an effective discriminator of populations with different growth rates (such as 4Vs and 4T cod). After collection of additional samples of spawning cod (see PRE objectives of Lambert), representing all potential residents/migrants into the area, the discriminant analysis used in 3.10 will be repeated with the inclusion of the new otolith shape data. Classification success will then be tested in a jackknife procedure. Note that this objective cannot be met with existing equipment. (Campana, with Mohn, Lambert, Zwanenburg, Chouinard)
  9. In support of the departmental priority to determine the diet of seals, and given the reliance on otoliths found in seal stomachs to estimate fish consumption by species and size, prepare a photographic otolith atlas of fish species in the NW Atlantic. All NW Atlantic species would be included and represented by at least 3 length categories. The atlas could then be used by researchers analyzing seal stomach contents, as well as by archaeologists analyzing middens, and geologists analyzing sediment cores. Due to previous sample collections by Campana and Hunt, otoliths of 56 species have already been collected. (Campana, with Hunt, Bowen and Stobo)
  10. Continue analysis of data relating yearclass strength to early life history growth, if time permits. Estimates of yearclass strength will be derived from VPA while early life history sizes and growth rates will be backcalculated from the sequence of daily increment widths in the otoliths. (Campana, Neilson)
  11. Serve as consulting scientist for the Age and Growth Subproject of the Eastern Caribbean Flyingfish Project. Complete radiochemical age determination of flyingfish. (Campana, Hunte, Oxenford, Deane)
  12. Maintain and upgrade image analysis system for continued use with otolith preparations, as well as for Divisional and Branch requests. (Campana)
  13. Continue to serve as M.Sc. supervisor for D. Tully (Biology Dept., Dalhousie University). (Campana)

## 6. Background:

### Highlights:

The syntheses, workshops, symposia, and international attention now focused on otolith microstructure all indicate that it is no longer an emerging technology, but an accepted (and often preferred) approach for studying many aspects of the biology of young fish (Campana); Regional Citation for Excellence (Hamel).

### Selected Involvements:

#### i. Collaborative Research -

J. Smith (PCS), radiochemical age determinations; W. Hunte, H. Oxenford, R. Deane (Barbados), flyingfish; C. Jones (Virginia), D. Stevenson (Maine), J. Dean, D. Secor (South Carolina), A. Geffen (U.K.), J. Butler (California), otolith microstructure volume; E. Moksness (Norway), ICES

otolith microstructure workshop; J. Casselman (MNR, Ontario), cod stock structure study (otolith shape analysis); C. Jones (Virginia), black drum radiochemical age determination. (Campana)

ii. University Liaison -

Honorary Research Associate, Biology Dept., Dalhousie; Ph.D. thesis committee member for J. Tremblay (Dalhousie); M.Sc. thesis supervisor for D. Tully (Dalhousie) and R. Deane (Univ. West Indies). (Campana)

iii. Communications -

Filmed for CBC Newsworld, Cable 10; Interviewed for feature articles in Globe and Mail, MIT Technology Review, Canadian Science News, Discover magazine, Fish'n Canada News; Radio interviews on CBC, Radio Canada; interviewed for DFO article on otoliths and age determination; provided information on age determination to students from elementary schools and high schools; asked to write book review for Copeia. (Campana)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Campana, S.E., and E. Moksness. 1991. Accuracy and precision of age and hatch date estimates from otolith microstructure examination. ICES J. Mar. Sci. 48:

Smith, J.N., R. Nelson, and S.E. Campana. 1991. The use of Pb-210/Ra-226 and Th-228/Ra-228 disequilibria in the ageing of otoliths of marine fish. P. 350-359. In: P.J. Kershaw and D.S. Woodhead [eds]. Radionuclides in the study of marine processes. Elsevier Applied Science. N.Y.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Campana, S.E., and E. Moksness. 1991. The ICES Otolith Microstructure Workshop. Report to the ICES Recruitment Processes Working Group. 35 pp.

Jones, C.M., and S.E. Campana. 1991. Sources of bias in interpreting otolith-derived hatch date distributions. Proc. AFS ELH Meeting, Los Angeles, CA.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

It is once again evident just how much information can be gleaned from the detailed analysis of fish bony structures, particularly the otoliths. The work conducted under this project continues to attract world-wide attention and had opened exciting possibilities in enhancing our understanding of fish biological processes, both at the population and individual level. The association of otolith shape and stock structure is very exciting in that it appears that fish may have an internal tag that can be used to investigate stock relations, movements, and so on. This is a very successful research program.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 119

Section: Marine Mammals

Project Title: Finfish Tagging Studies

Project Leader: Stobo, W.

Other Researchers: Neilson, J.

Work Activity: W.A.1.1.1.2

Key Words: tagging; fish migrations; assessment research; fish distribution;  
groundfish1. Project Description:

Examination of movements of the major commercially exploited groundfish stocks (cod, haddock, pollock, plaice, halibut) in the Gulf of St. Lawrence and on the Scotian Shelf via shore based and vessel based tagging operations conducted between 1953-1984. Recoveries of tagged cod, haddock, and pollock are still being received.

2. Long-Term Objectives:

Elucidate movements and stock relationships of: i) cod in NAFO divs. 4T, 4Vn, 4Vsw, 4X, and eastern Georges Bank; ii) haddock in NAFO Div. 4X and eastern Georges Bank; iii) pollock in Subareas 4 and 5; and iv) plaice in the Gulf of St. Lawrence and on the Scotian Shelf. Provide review of tagging and results of work conducted on the Scotian Shelf and in the Gulf of St. Lawrence by the Scotia-Fundy Region on other less commercially important species between 1953 and 1986.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Commence analysis of 4X herring tagging data. (Stobo)

No progress made.

2. Completion of paper on herring movement in NAFO Divisions 4T/4Vn. (Stobo, plus external collaborators)

Not completed. No progress made by co-author.

3. Completion of technical report on review of finfish tagging. (Stobo)

Not completed. In progress, analysis completed.

4. Completion of paper on flatfish movements. (Neilson, Stobo)

Not completed. Analysis complete, manuscript in preparation.

5. Completion of paper on factors influencing tag recovery. (Stobo)

Not completed. Analysis being redone using generalized linear approach.

6. Completion of paper on tag induced mortality in herring. (Stobo)

Paper completed and accepted for publication in J. Northw. Atl. Fish. Sci.

4. Additional Accomplishments:

Priority demands for information on the 4TVn stock relationships resulted in attention being focused there rather than on the items listed in the expected goals for 1991. Paper (verbal) for CCFR meeting in January, 1992, on Cod movements in 4RSTVnVsW (Stobo/Lambert) in preparation.

5. Goals/Expected Outputs for 1992:

1. Completion of paper on herring movement in NAFO Divisions 4T/4Vn. (Stobo, plus external collaborators)

2. Completion of technical report on review of finfish tagging. (Stobo)

3. Preparation of working paper on flatfish movements for CAFSAC and completion of manuscript for primary publication. (Neilson, Stobo)

4. Completion of paper on factors influencing tag recovery. (Stobo)
5. Completion of analysis of cod stock relationships in 4TVn and presentation of working paper to CAFSAC. (Stobo, Lambert)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -  
Fowler, G.M., and W.T. Stobo. 1991. Comparative recoveries of spaghetti tags and Petersen disc tags on Atlantic cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*). J. Northw. Atl. Fish. Sci. 11: 39-42.
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

As indicated in the 1990 PREP, progress in analysis and output from this project will be largely dependent on sustained technical support and dedicated involvement by other MFD staff. Involvement by the professional involved in 4Vn cod allowed the indicated progress to occur. Rate of output from this project will continue to be dictated by the level of Divisional support.

During the last two fiscal years, Dr. Stobo has managed to produce a fully edited tagging data base. To date, few individuals have accepted his offer for collaboration. During the coming year, an attempt will be made to provide focused resources to assist in the analysis of this extensive data base.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 121

Section: Marine Ecology

Project Title: Ecosystem Size Processes

Project Leader: Dickie, L.

Other Researchers: Boudreau, P.R. (FWA); Kerr, S.R. (HED)

Work Activity: W.A.1.1.1.7

Key Words: size-dependent production processes; fish distribution; availability;  
abundance1. Project Description:

Acoustic studies of size-dependent parameters of fish population distribution to enhance the measurement of abundance and the assessment of production.

2. Long-Term Objectives:

Utilization of acoustic techniques to characterize size-dependent regularities in fish populations in order to predict population production in relation to environmental and biological variables, and to forecast their behaviours under different management and fishery regimes. (An ongoing project).

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Begin field programs under OPEN. (Dickie)
2. Participate in the Eastern Shelf Program by using acoustic survey tools in cooperation with surveys for adult and juvenile fish abundance and distribution in the area. (Dickie)

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project is now being conducted almost fully outside of MFD, as part of the OPEN initiative. Dr. Dickie plans to retire in June 1993.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 122

Section: Pelagic Fisheries

Project Title: Large Pelagics Assessment and Associated Research

Project Leader: Porter, J.

Other Researchers: Dickson, C.

Work Activity: W.A.1.1.1.6

Key Words: large pelagics research; swordfish assessment

1. Project Description:

Research and assessment-related activities for large pelagic species (swordfish, tunas, large sharks) are undertaken with the primary objective of improving management advice. Personnel participate in ICCAT assessment process, and provide advice to zonal industry/management meetings. A research program is being undertaken to improve the biological basis for assessment and management.

2. Long-Term Objectives:

Provide the scientific basis for the management advice of the large pelagics fisheries (particularly swordfish). Conduct research in biology, population dynamics and assessment methodology to improve the quality of advice.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Participate in ICCAT assessment meeting for swordfish, and submit Canadian statistics on catch, size composition and effort, and provide scientific advice to the Canadian delegation. (Porter)

Porter collected and compiled individual weights of swordfish from industry and submitted these catch-at-size data along with Canadian landing statistics to ICCAT. Porter participated in the ICCAT swordfish assessment and SCRS. Porter was requested to be the swordfish scientific advisor to the Canadian Delegation to the ICCAT Commission meetings. Two SCRS documents and National Report were submitted.

2. Continue to provide advice to Scotia-Fundy swordfish working group, to SFLPAC and to members of industry on a more informal basis. (Porter)

Attended two ALPAC meetings (Feb. and Oct.) and one SFLPAC meeting and made five science presentations. Met with fishermen on two field trips to southwest Nova Scotia and maintained general contact.

3. Complete analysis of historical tagging data from Canadian large pelagics tagging program, including publication of two manuscripts. (Porter)

One manuscript is in review process (CJFAS) and a second is nearing final form for submission in 1992.

4. Institute the following projects in support of assessment: a) continue research to produce a sex-specific growth model to improve the assessment, using standardized sampling techniques (collaboration with NMFS); b) collect individual weights of swordfish directly from fishermen and buyers to provide detailed catch-at-size data for the assessment; c) investigate how to produce a standardized CPUE index relevant to the Canadian swordfish industry; d) continue investigation of use of oceanographic data to predict the location of swordfish. (with Perry/Page)

a) Conducted 4 months of commercial sampling (contract) and a cruise to collect sex at size data (in collaboration with NMFS); b) industry provided more detail on log records. Some buyers voluntarily provided tally sheets of individual weights of swordfish though not 100%; c) in collaboration with U.S.A. scientists, started to develop a long-term stock biomass index for North Atlantic (including Canadian) swordfish longline fishery; d) collected XBT and salinities for all longline sets on research cruise P420. Initiated discussion with Page regarding oceanography and swordfish distribution.

5. Undertake a cruise in August/September to meet several objectives including: a) collecting hard parts and fecundity data from known sex and size swordfish in order to collaborate with NMFS in ageing swordfish in the future; b) to add to the size/growth data sets; c) to collect data on swordfish behaviour (bait-robbing and attraction to artificial lights); d) to continue to collaborate with the ROM (genetic and growth studies). (Porter)

a) a research cruise (P420) was conducted in late September, but due to poor weather very few

swordfish were captured. Vertebrae, otoliths, finspines and gonads from the four fish captured were collected. Sampled commercial catch at sea (contract). More than 200 samples collected; b) all fish sampled were measured; c) collected limited data on swordfish bait-robbing and attraction to artificial lures during research cruise; d) continued to collaborate with ROM on genetic and growth studies on swordfish.

6. To continue the mark-recapture experiment on bluefin tuna in order to estimate the size of the Browns Bank aggregation. Further, although over 60 fish were tagged in 1990, none were recaptured. A full-scale tagging study should be continued to determine if this is a result of the dilution of the tagged fish in a very large population, extensive movement of fish through the Browns Bank area or death of fish due to tagging procedure. (Porter)

Continued bluefin tuna mark-recapture study in Hell Hole in order to provide an estimate of the size of the aggregation. Seven recaptures from 1990 were obtained and 71 fish tagged. The recaptures plus the use of sonic tags demonstrated that fish survive the tagging procedure. Preliminary results show considerable movement of fish through the Hell Hole and individual fish return to Hell Hole each year.

7. Complete work on strategies of recruitment in seabirds, complete supervision of M.Sc. student, complete study on development of parent-young recognition in kittiwakes. (Porter)

M.Sc. student in final stages of thesis writing - defense expected early 1992. Completed study on development of kittiwake parent-young recognition, resulting in one manuscript in press and a conference presentation.

#### 4. Additional Accomplishments:

1. Hosted and coordinated the 1991 ICCAT Swordfish Assessment Workshop in St. Andrews. This was an eight-day meeting involving 25 scientists from five nations. (Porter)
2. Successfully modified a DFO vessel with a longline drum to mimic swordfish surface longlining techniques of the commercial fleet. (Porter)

#### 5. Goals/Expected Outputs for 1992:

1. Participate in ICCAT assessment meeting for swordfish (22-29 Sept. 1992); SCRS (2-6 Nov. 1992) and provide advice to Canadian delegation at Commission Meeting (9-13 Nov. 1992). Submit Canadian statistics on catch, size composition and effort. (Porter)
2. Continue to provide advice to regional swordfish advisory committees and working groups. (Porter)
3. Complete and publish analyses of historical tagging data from Canadian large pelagics tagging program. (Porter)
4. Become more familiar with quantitative assessment techniques and the Canadian stock and assessment process. Acquire and set up ICCAT assessment files in St. Andrews and explore analytical assessment structure. (Porter)
5. Continue the following projects in support of assessment: a) continue collaboration with NFFS/ICCAT to produce a sex-specific growth model to improve the assessment; b) request that the Fisheries Act be used to obtain individual weights of swordfish from buyers in order to have 100% coverage, to provide detailed catch-at-size data for the assessment; c) continue collaboration with U.S.A. and Spanish scientists to develop a long-term stock biomass index for North Atlantic swordfish for use in a stock production model in the assessment. (Porter)
6. Undertake a cruise in August/September to meet several objectives including: a) collecting hardparts and fecundity data from known sex and size swordfish in order to collaborate with ICCAT scientists in ageing swordfish in the future; b) to add to the size/sex growth data sets; c) to collect data on swordfish behavior (bait-robbing and attraction to artificial lures); d) to continue to collaborate with the ROM. (Porter)
7. Complete seabird work at Memorial University including the successful examination of M.Sc. student. (Porter)
8. To continue the very successful mark-recapture experiment on bluefin in order to estimate the size of the Hell Hole aggregation (if B-based funding is available). Continuation of this study will also allow estimates of recruitment, migration and mortality. (Porter)

#### 6. Background:

##### Highlights:

Conducted a sampling program to investigate swordfish age and growth (commercial sampling and research cruise). Conducted a cooperative Industry-Science mark-recapture experiment on bluefin tuna in Scotia-Fundy. Collected size data on 1991 swordfish fisheries to supply ICCAT with catch-at-age (size) data. Hosted 1991 ICCAT swordfish assessment meeting. Participated in ICCAT SCRS and Commission meetings. (Porter)

##### Selected Involvements:

##### 1. Collaborative Research -

C. McGowan and J. Alvarado, Royal Ontario Museum; large pelagic growth and genetics; R. Anderson and A. Storey, Memorial University of Newfoundland, development of parent-young recognition in gulls; J. Neuman, Memorial University of Newfoundland, courtship feeding and sibling rivalry in

kittiwakes; Southwest Nova Tuna Association, bluefin tuna tagging study; R. Conser and J. Hoey, U.S.A., swordfish stock-biomass index; G. Scott and D. Lee, NMFS, U.S.A., ageing, growth and maturity of western Atlantic swordfish. (Porter)

ii. University Liaison -

Adjunct professor, Ocean Sciences Centre and Psychology Department, Memorial University of Newfoundland, NSERC operating grant \$20K per year, "Strategies of recruitment in seabirds: consequences for population regulation"; supervisor of M.Sc. student at Memorial University of Newfoundland; Liaison officer for DFO/NSERC Science Subvention research grant awarded to C. McGowan, University of Toronto. (Porter)

iii. Communications -

iv. Contracts Administered -

Scientific authority for "Field collection of biological samples from the commercial swordfish industry." S.C. Smith - \$ 12.0K; Scientific authority for "Enhancement of bluefin tuna multiple mark and recapture experiment on Browns Bank." Atlantic Reference Centre, HMSC - \$ 14.0K. (Porter)

v. Other -

Member of the Scotia-Fundy and Atlantic Large Pelagic Advisory Committees and departmental swordfish and bluefin working groups; scientific advisor to the Canadian delegation to ICCAT; Member of ICCAT Swordfish Working Group, Standing Committee on Research and Statistics, Subcommittee on Statistics, Subcommittee on the Environment. (Porter)

7. Publications:

i. Primary -

Storey, A.E., R.E. Anderson, J.M. Porter, and A. McCharles (in press). Absence of parent-young recognition in kittiwakes: a re-examination. Behaviour.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Clay, D., T. Hurlbut, and J.M. Porter. 1991. National report of Canada, 1989-90. Int. Comm. Conserv. Atl. Tunas, Rep. for Biennial Period 1989-90, Part 1: 412-418.

Clay, D., and J.M. Porter. (in press). National Report of Canada, 1990-91. Int. Comm. Conserv. Atl. Tunas, Rep. for Biennial Period 1990-91.

Conser, R.J., J.M. Porter, and J.J. Hoey. (in press). Casting the Shepherd stock-production model in a statistical framework suitable for swordfish stock assessment and management advice. Int. Comm. Conserv. Atl. Tunas Coll. Vol. Sci. Pap., Madrid.

Porter, J.M., and W.E. Hogans. 1991. A mark-recapture experiment of bluefin tuna (Thunnus thynnus L.) from the Browns-Georges banks region of the Canadian Atlantic. Int. Comm. Conserv. Atl. Tunas Coll. Vol. Sci. Pap., Madrid 35: 253-256.

Porter, J.M., and S.C. Smith. 1991. Literature review of differential growth and mortality in Atlantic swordfish, Xiphias gladius. Int. Comm. Conserv. Atl. Tunas Coll. Vol. Sci. Pap., Madrid 35: 445-448.

Porter, J.M., and S.C. Smith. 1991. Literature review of ageing in Atlantic swordfish, Xiphias gladius. Int. Comm. Conserv. Atl. Tunas Coll. Vol. Sci. Pap., Madrid 35: 449-458.

iv. Popular and Miscellaneous -

Porter, J.M. 1991. Large pelagics are back. Weekly Scientific Briefing 10(13): 2-3.

Porter, J. M. 1991. Second year of bluefin tagging completed. Weekly Scientific Briefing 10(43): 1-2.

8. Review and Evaluation:

The research program on large pelagics, particularly swordfish, has been re-established and is advancing our knowledge of these resources. The program has also relied heavily on industry involvement and thus has benefited from sources of information other than those normally used. There is still the outstanding issue of the Bluefin tuna mandate, which resides in the Gulf Region and for which no Scotia-Fundy resources are available.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 123

Section: Pelagic Fisheries

Project Title: Pelagic Acoustics Surveys

Project Leader: Buerkle, U.

Other Researchers: Trynor, J.; Dickson, C.

Work Activity: W.A.1.1.1.6

Key Words: resource surveys; assessment research; herring; acoustics

1. Project Description:

Research on acoustic methods is undertaken to modify and improve acoustic systems for finfish abundance estimates. Surveys are undertaken using acoustics to estimate fish abundance and results are used in stock assessments.

2. Long-Term Objectives:

Develop and apply acoustic methods for estimating distribution and abundance of fish (particularly pelagic) populations to improve the basis for fisheries management.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Coordinate Divisional acoustic program. Participate in CAFSAC and provide advise as required. (Buerkle)

The Divisional acoustic program was expanded to include a groundfish component. The new biologist responsible for the groundfish project was introduced to equipment and procedures and was advised on how to proceed with the project. Three acoustic herring surveys were carried out as planned and the results of the winter survey were reported to CAFSAC.

2. Conduct the annual winter Chedabucto Bay herring acoustic survey (Alfred Needler, 2-22 Jan. 1991) in support of the 4WX assessment. Report results to CAFSAC and produce a Res. Doc. (Buerkle)

The annual winter acoustic herring survey (N147, Jan. 3-28) resulted in 11 replicate estimates of herring abundance in the index survey area in Chedabucto Bay. The highest abundance 30,000 t was estimated the first night out (Jan. 5). This is about one-tenth of the abundance estimated in previous years. The following estimates averaged around 10,000 t. A random parallel line survey of a 680 km square area outside Chedabucto Bay found no herring. It was concluded that the herring left the area early this year. The results were presented to CAFSAC (Res. Doc. 91/57).

Another survey was done 3-13 Dec. 1991. This time, there were no herring in the Bay and only about 35,000 t were found outside the Bay.

3. Collect groundfish acoustic and biological data in area 4V (Alfred Needler, 22-29 Jan. 1991) to provide input to software development for target strength estimation and bottom discrimination. (Buerkle)

Acoustic and biological groundfish data were collected (N147, Jan. 22-24) in an area of commercial cod fishing off Sidney Bight. Twelve successful simultaneous bottom trawl and acoustic tows showed catches between 20 and 2100 kg were strongly correlated with acoustic area scattering in the bottom 5 m layer ( $r = 0.82$ ). This shows that there is good potential for groundfish acoustic work in the right place at the right time.

4. Conduct summer acoustic survey (Alfred Needler, Aug. 1991) to explore the potential for acoustic abundance surveys on spawning herring off SW Nova Scotia. (Buerkle)

The acoustic summer surveys were done with the E.E. Prince. The first (P417) surveyed the Scots Bay area from July 25 to August 2, the second (P419) surveyed in the German Bank area from Sept. 3 to Sept. 13. Both surveys were planned to be done in conjunction with the fishing fleet, but the fleet was not fishing during the Scots Bay survey. The surveys on German Bank were parallel line surveys overlaid on the distribution of fishing effort by the seiner fleet. The results of both surveys were disappointing, neither found the concentrations of herring expected. A draft manuscript report of the results has been written.

5. Complete acquisition assembly and testing of the 120 kHz dual beam acoustic system for groundfish and herring surveys. (Buerkle)

The FEMTO 120 kHz dual beam acoustic system took its maiden voyage in December on the Alfred Needler.

This system worked well except for an excessive noise level. The source of this has been identified as the power supply for the transducer preamplifier and remedial action is being taken. The system will go out again in Jan. 1992 to continue the evaluation and to collect dual beam data.

6. Develop methods and software to integrate the new features of the Femto model 9001 into survey data collection and processing by: (Buerkle)

A-developing software to determine in situ target strengths from dual beam data  
 B-developing methods of digital data editing to discriminate between fish and bottom echoes

A-The method and equations to determine in situ target strengths from dual beam data using calibration sphere measurements have been worked out. Development of the software applications is 50% complete.

B-The St. Andrews acoustic data processing software has been modified to work with the FEMTO model 9001 digital data editor. Bottom echos can now be removed with one of several bottom removal algorithms of the FEMTO editor. The best one of these for herring appears to be removing 0.5 m above the bottom pulse as has been done for some years.

7. Produce a paper on the effect of bottom editing on abundance estimates in herring (and groundfish). (Buerkle)

A paper on the effect of bottom editing on abundance estimates has not been produced. The very heavy load of sea time did not leave enough time to get to this.

8. Assemble 420 kHz version acoustic system for high resolution of groundfish near bottom and in herring for target strength. (Buerkle)

The problems encountered and the delays in completion of the 120 kHz system have led to second thoughts on proceeding with a 420 kHz system at this time. FEMTO Electronics felt it would be better to gain some experience with the 120 kHz system, particularly with noise and maximum depth, before developing a 420 kHz system. It also appears that towing the transducer at greater depths will be a bigger problem than originally envisioned.

#### 4. Additional Accomplishments:

#### 5. Goals/Expected Outputs for 1992:

1. Carry out the annual winter Chedabucto bay herring acoustic survey (Alfred Needler, 6-18 Jan. 1992). Report results to CAFSAC and produce Res. Doc. (Buerkle)
2. Continue acoustic system development by completing the software to process dual beam data to calculate in situ target strengths, and by testing and evaluating the FEMTO 120 kHz transceiver. (Buerkle)
3. Direct and assist in the groundfish acoustic initiative by planning projects and training personnel in acoustic methods. (Buerkle)
4. Collaborate with Jim Gale to incorporate digital acoustic survey data into the data base management scheme being set up at St. Andrews. (Buerkle)
5. Investigate the effect of different criteria of bottom echo removal on abundance estimates of herring and produce a manuscript for a primary publication, if results are suitable. (Buerkle).

#### 6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

To develop a 120 kHz dual beam echo sounder transceiver, \$30,000 FEMTO Electronics, Scientific Authority: U. Beurkle.

v. Other -

#### 7. Publications:

i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

Buerkle, U. 1991. Results of the 1991 acoustic herring surveys in NAFO Div. 4W, and revised results of the 1990 surveys. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 91/57.

Buerkle, U., and R.L. Stephenson. 1991. Herring school dynamics and its impact on acoustic abundance estimates. In Proceedings of the International Herring Symposium. Anchorage, Alaska, U.S.A., October 23-25, 1990. Alaska Sea Grant College Program Report No. 91-01, pp. 185-207.

Stephenson, R.L., M.J. Power, U. Buerkle, W.H. Dougherty, D.J. Gordon, J.B. Sochasky, and G.D. Melvin. 1991. Assessment of the 1990 4WX herring fishery. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 91/58.

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Acoustics is now well established as an essential ingredient of the pelagic assessments. In 1991, significant progress was also made on the development of a dual beam system. This was facilitated under AFAP. After many years of promise and little delivery, under the current research team, acoustics technology is finally finding a role in stock assessment.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1250

Section: Gulf of Maine

Project Title: Oceanography and Fish Distribution

Project Leader: Page, F.

Other Researchers: Losier, R.; Smith, S.; Gavaris, S.; Stephenson, R.; Smith, P. (PCS); Tee, K. (PCS); Loder, J. (PCS); Drinkwater, K. (PCS); Lynch, D. (Dartmouth College); Greenberg, D. (PCS); Werner, F. (SKIO); Sinclair, M. (BSB); Perry, I. (IOS); Tremblay, J. (BFAD); Lough, G. (WHOI)

Work Activity: W.A.1.1.1.2

Key Words: fish distribution; physical oceanography; recruitment; pelagic fish; fisheries ecology; biological oceanography; abundance indices; groundfish; transport; particle tracking; modelling

1. Project Description:

This project examines the influences of oceanographic variables and processes on the structure and dynamics of fish populations and aims to quantify the impact of these influences on indices of fish abundance, commercial catch characteristics, stock structure and recruitment. It explores methods to detect and predict oceanographic influences on the estimated distribution and abundance of commercial fish populations so natural influences can be distinguished from human influence. It includes the exploration of new sampling techniques such as remote sensing, monitoring by research surveys, modelling and making use of commercial operations.

2. Long-Term Objectives:

Develop an understanding of the influences of oceanographic variables and processes on the structure and dynamics of fish populations and quantify the impact of these influences on indices of fish abundance, commercial catch characteristics, stock structure and recruitment. Develop methods for detecting suitable environmental conditions for various stocks and for determining environmental effects on recruitment. Use the understanding to help predict fishing patterns, help modify research survey indices of abundance, and consequently assessments of population size, and help predict recruitment success which may have application in setting management advice.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Since this is my first year associated with this program, my general goal is to become familiar with the present goals of this program, the needs of the Division with respect to this program, and to review the focus of this program in the context of these needs and my expertise. Several of the more specific goals of this program are those inherited from Ian Perry's work plan (Project No. 1250, PREP 1990/91). Ian intends to pursue these in collaboration with S. Smith. I have been invited and intend to define my involvement as time permits, during the latter portion of the year when it will be clear how much Ian can accomplish from afar.

By attending STABS/MFD staff meetings and talking with MFD personnel, I reviewed and gained familiarity with the goals of this program as defined by I. Perry and with the needs of the Division with respect to this program. Several of the goals defined by I. Perry have been pursued (see below).

2. As time permits continue my participation in the Georges Bank Frontal Study (Project 1250 #1, PREP 1990/91, Perry). My participation in this differs from that of I. Perry's. I will continue exploring the relationships between Eulerian and Lagrangian measurements of the circulation on the Northeast peak of Georges Bank with emphasis on our ability to i) detect hydrographic convergence/divergence features and ii) evaluate the influence of these features on pollutant and fish early life stage dispersal. This work will be conducted in collaboration with J. Loder (PCS) and K. Drinkwater (PCS). No milestones are envisioned since progress will depend on the time available.

Eulerian and Lagrangian data sets were gathered but no analyses were conducted due to a lack of time.

3. Begin my involvement with the interdisciplinary, NSF funded GLOBEC (Global Oceans Ecosystems Dynamics) project on cod, haddock and scallop larval dispersal on Georges Bank (Project No. 1250 #2, PREP 1990/91, Perry). The goal of this project is to examine the influence of hydrographic and meteorological conditions on the dispersal of the early life stages. This will be accomplished by developing 3D baroclinic circulation and particle tracking models. My involvement will focus on i) implementing a review and collation of relevant biological data, ii) exploring and implementing methods for integrating these data into a 3-D particle tracking model based upon a baroclinic circulation model being developed as part of the physical

component of this project and iii) conducting preliminary runs of the particle tracking model. This work will be conducted in collaboration with a team of physical and biological oceanographers. (Loder, Greenberg, Lynch, Werner, Sinclair, Trembley, Perry, Lough)

Progress within this project is on target for a late 1992 or early 1993 completion date. I completed a review of MARMAP cod and haddock larval horizontal distribution data for the Georges Bank area, contributed to a summary of the early life stage characteristics of cod and haddock on Georges Bank, assisted in the development of a particle tracking algorithm for finite element models, directed the development of an early life stage vertical migration behaviour subroutine incorporated into the particle tracking model, conducted preliminary runs of the particle tracking model and supervised the production of bottom contours incorporated in the displays of tracking model output. I also participated in two project team workshops and visited the Skidaway Institute of Oceanography to pursue the development and testing of the tracking model.

4. Begin an investigation concerning how hydrography influences groundfish research vessel survey and assessment estimates of fish abundance (Project No. 1250 #3, PREP 1990/91, Perry). This multi-year program was initiated by I. Perry and S. Smith for the purpose of devising and evaluating ways of improving groundfish survey estimates of abundance using hydrographic information. In addition to potentially defining my involvement with some of their existing initiatives (see PREP 1989/90 Project No. 1250), toward the latter part of the year I hope to focus on the aspect of how hydrography influences survey abundance estimates rather than on defining fish hydrographic preferences. (Page, Gavaris, Smith)

Plots of bottom temperatures and salinities measured during standard groundfish surveys were produced in conjunction with Project 1270, plots of the age specific distributions of cod and haddock within 5Z were produced from the groundfish survey data base, interannual variation in the patterns of bottom temperature within 5Z were qualitatively compared with survey catches of cod and haddock, an exploratory analysis of the relationship between time of day and RV cod and haddock bottom trawl catches was initiated, and exploratory simulations of the effect of distribution and sample size changes on estimates of abundance obtained from stratified random surveys were conducted.

5. Plan a field study to describe the small-scale variability in bottom trawl fish catches and relate this to hydrographic and meteorological variables such as tidal current speed and direction, depth, light, wind, temperature and salinity. (Page, Gavaris, Hunt). (This is an extension to Perry's Project No. 4, PREP 1990/91)

The merits of conducting this field program were considered and it was decided a prudent approach would be to first analyze existing groundfish survey and RV data to determine if relationships between trawl catches and hydrographic and meteorological variables are evident and to participate in P. Hurley's 1992 field program, in collaboration with D. Clark, to gain experience in field protocols and the potential of acoustics to examine these interactions. P. Hurley has an ongoing field program with similar objectives (Project 9765).

6. Continue the development of a larval herring dispersion model and conduct analyses of existing data concerning larval herring vertical distribution and related physical oceanographic data. This work will be conducted as part of the LaHOPE (Larval Herring and Ocean Physics Experiment) project which has the general goal of developing an improved understanding of the physical and biological dynamics influencing larval herring dispersal in the SW Nova Scotia region so that i) the practical problems of inferring stock discreteness and stock size from the annual larval herring surveys can be more fully addressed and ii) the mechanisms underlying the 'retention hypothesis' can be explored. Results from this work will be presented at the annual Canadian Meteorological and Oceanographic Society meeting and at the annual summer meeting of the American Society for Limnology and Oceanography. (Page, Stephenson, Tee (PCS) & Smith (PCS)).

Models of vertical larval herring distribution were developed and exploratory analyses of existing larval vertical distribution data were continued. An overview of the objectives and achievements of the LaHOPE was presented at the annual CMOS meeting and specific modelling achievements of the program were presented at the annual ASLO meeting.

7. Participate as a member of the PCSB/BSB Aquaculture Environment Working group.

I had no involvement with this committee since PCS has yet to call a meeting.

#### 4. Additional Accomplishments:

Attended the groundfish CAFSAC meetings to gain exposure to assessment procedures and issues.

Participated, by invitation, in the U.S. GLOBEC Implementation Workshop.

Visited the University of New Brunswick's Ocean Mapping group to become exposed to their activities and to explore the potential for future interactions and collaborations.

Attended an in house workshop on SQL\*PLUS usage.

Presented an overview of the use of particle tracking models in fisheries oceanography at the Skidway Institute of Oceanography.

Presented an overview of the GLOBEC modelling project at the PCS/BIO Friday seminar series.

Participated in a DFO Scotia-Fundy Inshore/Offshore Lobster Workshop and contributed comments to the report produced from this meeting.

Invited to present a seminar at Mont-Joli, PQ, on March 11, 1992 on GLOBEC Modelling Project.

## 5. Goals/Expected Outputs for 1992:

1. Continue to conduct analyses of existing groundfish survey and RV data to determine if relationships between trawl catches and hydrographic and meteorological variables are evident and how these may influence indices of abundance. Explore the use of tidal models for estimating near bottom currents at the times and locations of RV bottom trawl samples and then examine the relationship between bottom current and trawl catch. Examine the time and location of groundfish survey tows in relation to the time of day, phase of the tide and distribution of hydrographic variables in an effort to define biases in sample distribution. (Page, Losier, Strong, Trippel, Gavaris)
2. Participate in inshore 4X 1992 field program (Project 1012), in collaboration with D. Clark, to gain experience in field bottom trawling operations, to assess the potential of existing acoustic gear to detect groundfish, and to conduct a pilot investigation into the small scale variability of groundfish trawl catches. (Page, Clark, Hurley, Losier)
3. Continue involvement with the GLOBEC modelling team by continuing development of early life history vertical behaviour algorithms, assisting in the completion of particle tracking model runs designed to test to projects null hypothesis, collaborating in the preparation of manuscripts describing the project and its results and participating in GLOBEC team workshops. (Page)
4. Continue my involvement with the LaHOPE team by continuing development of larval herring vertical distribution models, continuing analyses of existing larval vertical distribution data in collaboration with members of the LaHOPE team, modifying the LaHOPE particle tracking computer code so it will accommodate higher resolution circulation input, conducting exploratory particle tracking runs using modified LaHOPE particle tracking code and participating in LaHOPE team workshops. (Page, Stephenson, Tee & Smith)
5. As opportunities and time permit measure the sinking rate of cod/haddock eggs produced by captive adults at STABS and adults collected and striped at sea. Potential participation in a cruise to Georges Bank aimed at investigating spawning dynamics of cod and/or haddock may provide such an opportunity. (Trippel, Clark, Page)
6. Write up descriptions and analyses of the drifter data base if time permits. (Page, Losier)
7. Continue my involvement with the Georges Bank Frontal study by exploring the relationships between Eulerian and Lagrangian measurements of the circulation on the northeast peak of Georges Bank if time permits. (Page, Drinkwater, Loder)
8. Participate as a member of the PCSB/BSB Aquaculture Environment Working group if this group becomes activated. (Page)

## 6. Background:

### Highlights:

Gained exposure to fisheries assessment issues and procedures by attending the 1991 CAFSAC meetings. Gained national and international exposure by presenting papers at the annual CMOS and ASLO conferences as well as invited presentations at Mont-Joli, PQ and SKIO, U.S.A. Established research connections through participation in the multi-disciplinary international GLOBEC modelling project and in the U.S. GLOBEC Field Program Implementation Workshop.

### Selected Involvements:

#### i. Collaborative Research -

Member of the PCS AFAP EDP working group and the CMOS Program Committee organizing the 1993 annual CMOS congress. Elected Co-chairman of the CMOS FOSIG.

Attended a special meeting between selected MFD personnel and FDR (a National Sea Products Subsidiary) concerning groundfish survey methodology.

Collaborated with Dr. D. Lynch at Dartmouth College (NH, U.S.A.), Dr. F. Werner at SKIO (GA, U.S.A.), Dr. G. Lough (NMFS, U.S.A.), Dr. I. Perry (PBS), Dr. J. Tremblay (BFAD), Dr. M. Sinclair (BSB), Dr. D. Greenberg (PCS/BIO) and Dr. J. Loder (PCS/BIO) in the development of the GLOBEC particle tracking model. Collaborated with Dr. P. Smith (PCS/BIO), Dr. K. Tee (PCS/BIO) and Dr. R. Stephenson (MFD) in the LaHOPE.

#### ii. University Liaison -

Initiated contact and discussed collaboration potential with Dr. R. Robson (Computing Science, UNBF) and Dr. M. Thomas (Science, UNBSJ). Graduate committee member for student of Dr. K. Thompson (Oceanography, DAL).

#### iii. Communications -

Collaborated on an article describing particle tracking and the LaHope Project for DFO's Weekly Scientific Briefing.

#### iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This program addresses the fundamental issue of how oceanographic variables and processes influence the structure and dynamics of fish stocks, RV indices of fish abundance, commercial catches and recruitment. Efforts during this first year were largely focused on becoming familiar with MFD issues and data bases, conducting exploratory data analyses and gaining national and international exposure. In the coming year the focus will be on data analyses, the establishment of relationships between oceanographic variables and fish distribution and the influence of these relationships on indices of abundance.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 126

Section: Gulf of Maine

Project Title: Juvenile Fish Ecology and Surveys

Project Leader: Neilson, J.

Other Researchers: Perley, P.; Zwanenburg, K.

Work Activity: W.A.1.1.1.2

Work Activity: juvenile surveys; resource surveys; recruitment; groundfish;

1. Project Description:

Conduct juvenile surveys, with particular emphasis on the Gulf of Maine area. Maintenance of data base for those surveys. Experimental work including vertical distribution studies and complementary laboratory studies using live animals. Analysis of survey and experimental data to determine distribution, behaviour, mortality, and growth of juvenile gadids in order to develop accurate pre-recruit abundance indices and further understanding of recruitment processes. Maintenance of larval/juvenile rearing facility at St. Andrews.

2. Long-Term Objectives:

Enhance understanding of the juvenile and larval ecology of commercially-important gadids. Such data are critical in the design of pre-recruit surveys and in gaining a better appreciation of factors affecting year-class strength.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Act as Thesis Advisor and DFO Science Subvention Liaison Officer for R. Rangeley. (Neilson)

Completed. R. Rangeley's thesis investigations of the role of algal macrophyte cover on juvenile pollock production is nearing completion and his work is receiving higher profile due to recent industry initiatives to harvest Ascophyllum nodosum in New Brunswick.

2. Write-up of larval cod condition study. (Neilson, Perry)

Ongoing. As time permits in 1992, a first draft of this manuscript will be forthcoming.

3. Maintenance of larval fish rearing facility and adult brood stock. (Perley, Sampson, Neilson)

This work proceeded well, and resulted in the availability of significant research material for investigators both within and outside of the Department.

4. Conduct an exploratory juvenile gadoid survey on the Eastern Scotian Shelf. Emphasis will be on locating aggregations of juvenile cod and haddock, ie. ages 1-2 and secondarily age 0, and determining effective means of quantitative sampling. A combination of bottom and mid-water trawling with gear suitable for capture of juvenile fish will be used in conjunction with an acoustic fish counting system. (Fanning, Zwanenburg, Dickie)

Budgetary constraints, in particular a substantial reduction in overtime allocation, required reduction of Divisional at-sea commitments, and initiation of this project was postponed until 1992. Resignation of the lead investigator in the interim now requires indefinite postponement of the project, and no goals are established for 1992.

4. Additional Accomplishments:

1. The Basins project involving Neilson with Sameoto (BOD) and Herman and Cochrane (PCSB) was published in CJFAS.
2. A contribution to a manual describing current techniques for otolith microstructure examination was completed. (Neilson)

5. Goals/Expected Outputs for 1992:

The goals of this project have been subsumed under Project 1350, Dynamics of Recruitment Processes for Gulf of Maine Gadids. Please refer to the description of Project 1350 for a description of goals formerly attributable to this project.

6. Background:

**Highlights:**

The continued extensive involvement with University researchers by both Trippel and Neilson was a highlight of the year. In one instance, collaboration with a St. Mary's investigator will result in the first published description of the fungal flora of cod eggs.

**Selected Involvements:**

## i. Collaborative Research -

See primary publication.

## ii. University Liaison -

McGill University (C. Chambers, Doug Bertram, D. Kramer), Dalhousie University (I. von Herbing, C. Taggart, S. McLatchie), St. Mary's University (T. Rand), Memorial University (G. Fletcher)

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

**7. Publications:**

## i. Primary -

Cochrane, N.A., D. Sameoto, A.W. Herman, and J. D. Neilson. 1991. Multiple-frequency acoustic backscattering and zooplankton aggregations in the inner Scotian Shelf Basins. Can. J. fish. Aquat. Sci. 48: 340-355.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

In the current funding environment, it is unlikely that much work will be done in the near future. This is unfortunate given the importance of this life stage to the population and thus the fisheries.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 127

Section: Southern Shelf/Gulf of Maine

Project Title: Oceanographic Data Handling

Project Leader: McRuer, J. (Collection); Page, F. (Processing)

Other Researchers: Branton, R.; Reid, J.; Simon, J.; Losier, R.

Work Activity: W.A.1.1.1.7; W.A.1.1.1.2

Key Words: resource surveys; data processing

1. Project Description:

Provision and maintenance of Divisional oceanographic gear. Provision and maintenance of Divisional oceanographic data bases for standard hydrographic data collected by Divisional programs.

2. Long-Term Objectives:

Provide on-going maintenance and replacement of Divisional sea-going oceanographic equipment to user programs. Ensure high-quality collection and archiving of hydrographic data in a Divisional data base. Forward hydrographic data to MEDS as required.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide, maintain and develop oceanographic equipment for MFD cruises. (McRuer, Reid)

Oceanographic equipment was provided for twenty six cruises in 91/92. Equipment maintenance was handled primarily by J.Reid with assistance from divisional staff overhauling equipment required for one series of summer cruises. Time constraints prevented a more structured maintenance schedule (and associated required training) enabling other staff to assist in general maintenance which would improve things considerably. Assistance for shipboard installation of equipment was provided by sea-going personnel for all cruises. This was generally good, however, but was inadequate at times due to lack of training or the availability of staff. The divisional equipment worked reasonably well this year ... some notable exceptions were the SCANMAR during the summer survey, the continued clumsiness of the Seabird software and thermometers and bottles which continue to cause headaches. Cooperation with P. Vass and D. Reimer of HED beneficial to both divisions and was essential for some of the cruises. This reinforces again our plea for EL support.

2. Ongoing MFD integration plan: a) refine integration of MFD cruise preparation, appropriate personnel and training; b) maintain inventory of personnel cruise experience & training to assist in staff selection for cruises; c) implement pre-cruise meetings with chief scientist - J.Reid - Institute facilities at least 6 weeks prior to cruise to iron out potential problem areas and enable smooth pre-cruise preparation; d) provide short courses for common ship board systems to include - cables and cable splicing, Electronic meter block system, Rosette water sampling system, - winches - basic hydraulics - electronics - connectors - EM cables - slippers - etc. (McRuer, Reid); make arrangements with St.Andrews staff (Mike Strong) to formulate a plan for co-ordination of cruise preparation for MFD cruises. (McRuer)

The integration of cruise preparation with Scotia Fundy Ships Division is working reasonably well. Wires get crossed occasionally, but cooperation from Ships Div has been good. Within MFD there are still some things to iron out. The pool of fully trained personnel is still too small and time too limiting for full integration of cruise preparation, appropriate personnel and training. Training of staff during the review period suffered due to time constraints and was limited to one formal session on the CTD and SCANMAR systems, a few informal unstructured sessions and pre-cruise demonstrations. To build a pool of fully trained personnel and enable a fully integrated approach, this will have to change. Work has begun on manual/coarse outlines but this too is going slowly. An inventory of staff with cruise experience and training has been started but is still very rudimentary and will require more time and thought to be useful. There were pre-cruise meetings/phone calls for some cruises but these were sometimes held to late, leading to a few pre-cruise scrambles. They are well worth the effort and combined with a basin gear trial should lead to better cruises all round. The coordination of cruise preparation with STABS continues to be done by direct interaction of BIO staff (Jeff/Jim) with the chief scientist.

3. Tension mode to the new cable entrapment block continuing (Reid)

The tension mod for the cable entrapment block continues slowly. Difficulty with the specs of one of the components, time constraints and dependence on non divisional staff continue to dictate the projects progress.

4. Establish protocols for data handling - at sea and on shore. Consideration is being given to

improved software to help meet this goal. (McRuer)

Protocols for data handling have been written and are to be implemented for the February groundfish cruise. Software has improved but cannot be finalized until promised software updates from the company arrive.

5. Develop a small depth/temperature system with external flow and pitch using netminder technology for compatibility of hard and software. (McRuer)

The design work and the necessary machining for the depth/temp/pitch system are completed. Still required to be completed is a downsizing of existing electronic boards. Dependence on non divisional staff will dictate completion.

6. Update SCANMAR trawl measurement system to full survey potential. (McRuer)

The SCANMAR trawl measurement system did not reach its full survey potential this year. Equipment failures and financial constraints prevented this, in fact no data was collected on the first leg of the summer survey. The equipment has been repaired and some necessary components acquired which should enable the system to be used at close to its full configuration on the Feb/Mar survey.

7. Compare and evaluate in-house vs. PCSB "Pipe" system for editing CTD data. Streamline and automate handling of survey hydrographic data, from collection to updating the data base, as much as possible. Prepare documentation on the collection, processing, and data base management protocols for oceanographic data, including the processing algorithms and the OCEANS data base. (Losier, Perry).

The hydrographic data editing procedures were reviewed, including a comparison and evaluation of in-house vs PCSB "Pipe" software system for editing CTD data, and pilot versions of level I and II edits are being prepared for February/March 1992. General documentation and protocols concerning oceanographic data processing and data base management are being prepared in conjunction with an update of the Division's groundfish manual. Detailed documentation on data processing algorithms are being prepared as aspects of the algorithms are finalized.

8. Receive, organize, process, and load into the OCEANS data base the oceanographic data collected during standard groundfish surveys. (Losier)

Hydrographic data from four standard groundfish survey cruises were processed and loaded into the Division's hydrographic data base, GSHYD.

9. First year goal is to become familiar with the operations associated with this program, the needs of the Division with respect to this program, and to review the workings of this program in the context of these needs. Most of the more specific goals of this program are those inherited from I. Perry's work plan. Since most of the equipment and sea-going responsibilities are the direct responsibility of J. McRuer and J. Reid, emphasis will be placed on the data processing, data analyses, archiving and documentation aspects of this project. (Page)

To become familiar with the Divisional needs and operations associated with this program, I discussed the program with members of the Division and held a meeting of the Ocean Data Handling Group. The mandate and issues relevant to this program were reviewed and discussed and suggestions for the structure and function of the group within the reorganized MFD were formulated. Minutes of this meeting were distributed to Section Heads. Intentions are to hold a follow-up meeting early in the new year to further discuss issues associated with the operation of this group and new issues associated with the implementation of the reorganization of MFD.

10. Participate as a member of the AFAP funded PCS EDP (Ocean Climate Monitoring Working Group) which has a multi-year mandate to i) develop an oceanographic data base for the Scotia-Fundy Region, ii) use this data base to characterize the climate of the Scotia-Fundy Region, iii) devise and recommend appropriate schemes for the future monitoring of the oceanographic climate in the Scotia-Fundy Region, and iv) develop data products from this data base that are of use to clients such as fisheries assessment groups, fisheries management groups and fisheries researchers. In the 1991/92 MFD fiscal year, the group hopes to finalize the development and implementation of the data base software and begin preliminary analyses of the data for the Gulf of Maine. (Page)

Attended all general meetings of the PCS AFAP EDP Working Group. The progress of this group is documented in monthly reports prepared by Clive Mason (PCS) and sent to Robert O'Boyle (MFD). These are compiled with reports from other AFAP projects and distributed to staff by R. O'Boyle. The development and implementation of the pilot data base and analysis software has been completed and preliminary analyses of the data for the Gulf of Maine begun. Preliminary results were presented to NAFO by Ken Drinkwater and a request to present an overview of the project was made to CAFSAC.

11. Prepare a preliminary summary of the groundfish survey hydrographic data for potential availability to assessment personnel and presentation at 1992 CAFSAC. This may include an analysis to identify temporal and spatial trends in hydrographic variables (temperature and salinity), strata specific anomalies for variables (temperature and salinity), strata specific anomalies for the most recent years, a comparison with available long-term hydrographic indices being maintained by the AFAP Ocean Climate Monitoring Working Group and produce a climatic update document for submission to the 1992 CAFSAC meetings. Hopefully, this will be available for distribution to assessment personnel several months prior to the meetings so assessment personnel can more easily make connections between hydrography and their assessments. This work may be conducted in collaboration with the PCS AFAP EDP Working Group. (Page)

Preparation of the preliminary hydrographic summary is on target for a February-March completion. Computer routines for calculating and displaying strata-specific mean and median temperatures and salinities and the associated annual anomalies for the standard groundfish cruises have been written and tested. Preliminary results were presented at the STABS PREP and the results for Georges Bank have been discussed with personnel assessing the Georges Bank cod and haddock stocks.

12. Act as a liaison between the PCS AFAP EDP Working Group and Austin Oake of FRD to keep him informed of the issue of establishing mechanisms whereby ocean information from the fishing fleets, both domestic and foreign, could be incorporated into the DFO regional data base. (Page)

Austin Oake was and is updated on the progress of the PCS AFAP EDP Working Group by sending him copies of monthly progress reports, generated by Clive Mason (PCS) and Robert O'Boyle (MFD), and the annual progress summary. The working group chairman, Ken Drinkwater (PCS), also communicates progress to Mr. Oake.

#### 4. Additional Accomplishments:

1. Equipment improvements: new printed circuit boards built to extend the life of the MSI2200 weight scale and the meter block systems; hub design for meter blocks improved; hall effect test box designed and built to test block assemblies. (McRuer)
2. Edits of historical hydrographic bottle data collected during groundfish cruises was continued and will be loaded into the Division's hydrographic data base in early 1992. (Losier)
3. The DB-GUIDE editing system was implemented for the divisional hydrographic data base, GSHYD. This provides a record of data edits made to data within the GSHYD ORACLE data base. (Losier)
4. The groups ability to process and interpret oceanographic data was expanded by sending Randy Losier on training workshops concerning bottom trawl performance and the processing of satellite imagery. (Losier)
5. Upgraded MFDs/STABSS archives of hydrographic data to include a complete Prince 5 hydrographic data set (1924-present). (Page)

#### 5. Goals/Expected Outputs for 1992:

1. Provide, maintain and develop oceanographic equipment for MFD cruises. (McRuer, Reid)
2. Ongoing MFD integrated cruise prep plan: a) continue with the integration of MFD cruise preparation, appropriate personnel and training; b) set up a data base of MFD personnel, cruise experience, and training; c) ensure pre-cruise meetings/phone calls with chief scientist - J.Reid and Institute facilities when required be held at least 6 weeks prior to cruise to iron out potential problem areas and enable smooth pre-cruise preparation; d) institute Basin gear trials for all cruises using divisional gear; e) set up a curriculum of short courses for common ship board systems and maintenance procedures; e) make arrangements with St.Andrews to formulate a plan for coordination of cruise preparation for MFD cruises. (McRuer)
3. Complete tension mod to the new cable entrapment block. (Reid)
4. Modify the hydrographic booms on the Alfred Needler and E.E. Prince to enable easier and safer operation of hydrographic gear. (Reid)
5. Update of SCANMAR to full survey potential continuing. (McRuer)
6. Convene a meeting of the ODH group to discuss and review the operation of ocean data handling procedures and any new issues associated with the operation of this group. (McRuer, Page)
7. Respond to inquiries concerning hydrographic data handled by this group. (Losier, Page)
8. Continue to collect hydrographic data on a monthly basis from Prince Stations 5 and 6. (Losier, Page).
9. Continue to oversee the organization, maintenance and development of the STABSB Fisheries Oceanography Laboratory. (Losier, Page)
10. Edit hydrographic data from standard groundfish surveys and maintain Division's hydrographic data base. (Losier)
11. Complete development and documentation of level 1 and 2 hydrographic data editing software. (Losier and Page).
12. Encourage the development of a stable field protocol for CTD operations. (Page, McRuer)
13. Continue to participate as a member of the AFAP funded PCS EDP (Ocean Climate Monitoring Working Group). In 1992, the group hopes to finalize the development and implementation of the data base software, complete acquisition of historical data, begin analyses of the data for the entire Scotia-Fundy Region and increase the attention given to fisheries-physical interactions. Progress may be hindered by a lack of funds since AFAP funding for the 1992/93 fiscal year has not been established. (Page)
14. Update and improve the summary of the groundfish survey hydrographic data prepared for distribution to assessment personnel. (Page, Losier)
15. Continue to update Austin Oake of the progress within the PCS AFAP EDP working group if 1992/93 AFAP funding is received and the group continues to exist (Page).
16. Evaluate the need for updating GSHYD with existing MEDS XBT data. (Losier, Page)
17. Explore the possibility of incorporating hydrographic data from standard pelagic surveys into the ORACLE data base. (Losier, Power, Page)

#### 6. Background:

**Highlights:**

J. Carscadden NWAFC -- assisting in refit of Lady Hammond for northern cod; Dr. Taggart et al. -- assisting in planning and equipment for OPEN project. (McRuer)

The successful change of Project Leaders from Ian Perry to Fred Page, the editing of standard groundfish cruise hydrographic data, the updating of the GSHYD data base with historical bottle data, the review of data editing procedures, the establishment of group meetings and regular communications between the BIO and STABSB members of this project group, the initiation of training sessions and the preparation of a hydrographic data summary. (Page)

**Selected Involvements:**

## i. Collaborative Research -

Dr. Gregory (PCSB-data handling and editing); P. Smith (PCSB-data editing); AFAP EDP working group (data base management). (Page)

## ii. University Liaison -

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

**7. Publications:**

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

The 1991 calendar year has been a successful transition year for this group. The Project Leaders have changed (Fred Page replacing Ian Perry), the Division has undergone a reorganization and a new management structure at the Biological Station is expected. Much of my time was spent acquainting myself with the issues facing the group, the workings and personalities of the group, and with clarifying the linkages to other groups and Divisions. Despite these uncertainties and delays, the group has successfully delivered the expected services, has begun to formulate and implement more efficient and effective service delivery protocols and is in the process of defining a more effective group structure that will hopefully operate smoothly within the new reorganization scheme. Hydrographic data editing procedures have been improved and evaluated, training sessions on hydrographic data collection and processing have been planned, the preparation of a hydrographic data summary has commenced, frequent communication between members of the ocean data handling group at BIO and STABSB have been encouraged and interaction with other divisions has been pursued. In the following year reorganization issues should be fully resolved so the group should be able to finalize its operational structure, complete the development and documentation of hydrographic data collection and editing procedures and proceed with the production of useful data summaries.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 128

Section: Administration

Project Title: Pelagic Fisheries Management Studies

Project Leader: Iles, D.

Other Researchers: None

Work Activity: W.A.1.1.1.6

Key Words: pelagic fish; herring; ecology and evolution

1. Project Description:

A documentation and summary of 40 years of fisheries research on three continents to ensure that data, concepts, ideas and interpretations accumulated and developed over this period are made available to any other interested scientist with common interests.

2. Long-Term Objectives:

The selection of the most significant subjects and the preparation and submission for publication of manuscripts, both solely and in collaboration with other scientists.

The publication of a book to be called "The Ontogenetic Imperative" that examines the interaction of ecological and evolutionary theory, based largely on the research in fisheries biology in relation to fisheries management.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete six essays on evolution and ecology for review as potential manuscript for a book. (Iles)

Circumstances beyond my control caused changes both in long-term goals and the way these would be approached during 1991.

I will now be producing a sample chapter for the proposed monograph, together with an outline of the work as a whole. It is now possible to indicate the full scope of my treatment and its implications and importance.

These will be passed to selected reviewers both in and outside the Department and submitted to publishers to solicit a contract.

The sample chapter is entitled "The imprudent predator and the impalpable parameter" and the title of the monograph as a whole "The Ontogenetic Imperative."

4. Additional Accomplishments:

1. The planning of a draft manuscript dealing with critiques of the "retention zone" theory of Iles and Sinclair. This issue has been raised in several contexts during the year, and must be addressed as it is relevant to the conceptual basis of major research programs supported by both the Canadian and U.S.A. governments. (Iles)
2. The completion of a draft manuscript on the variation in seasonal condition, and the evaluation of methodologies used to analyze seasonal physiological processes. (Iles)
3. The completion of revision of the Parsons manuscript on herring management. This was both unwelcome and unexpected and took up much of my time and virtually all the technical assistance at my disposal for 1991. This to the detriment of my own research program plans. (Iles)
4. The publication of a joint paper (with Dr. Bradford) on the biology of the Minas Basin herring stock, and the initial work on a second paper on the larval biology and distribution. (Iles)
5. The examination with Dr. Trippel, of the history and validity of the concept of the "cost of reproduction"; this was sufficiently advanced and complete to allow plans for publication in 1992. (Iles)
6. The publication of a paper on the herring stock of Minas Basin, Bay of Fundy. (Iles)
7. The identification and initial preparation of several earlier manuscripts for listing and future publication. (Iles)

8. The production of a draft (with R. Lozier and I. Perry) documenting the drifter data base. (Iles)

5. Goals/Expected Outputs for 1992:

1. Find publisher and possibly technical support for the proposed monograph. (Iles)
2. Publication of manuscripts prepared in 1991: a) Frankly Speaking - a reply to a critique; b) The Seasonal Variability in the Condition Factor of 4WX Herring and its Interpretation. (Iles)
3. Prepare and submit selected manuscripts in 1992: a) Stock/recruitment analysis of cod stocks to demonstrate the validity of the Iles' recruitment diagnostic method; b) The Minas Basin herring larval distribution and biology (with R. Bradford); c) The cost of reproduction, an outmoded concept (with E. Trippel); d) The Iles-Sinclair "retention theory" a ten-year review (with M. Sinclair; e) The "Condition Factor" in the analysis of seasonal physiology - a perspective paper for Balon's journal. (Iles)
4. Continue documentation of accumulated historical material to ensure its future availability. (Iles)

The extent to which these goals can be achieved will depend on the level of available support.

6. Background:

Highlights:

1. I am now convinced that I have a sustainable argument as a basis for a radically new monographic treatment of fisheries management and fisheries biology in relation to ecological and evolutionary theory.

Orthodox ecological and evolutionary theory have not benefited from the vast amount of fisheries related research data now available and, more importantly, cannot contribute to the solution of the two most important outstanding questions in fisheries of stock structure in marine fishes, and the stock-recruitment problem. It is in these areas that I have made my most significant contributions, and I can now put this in the widest possible context.

The scope of the proposed "Ontogenetic Imperative" is now essentially clear and comprehensive. However, with the available resources, it is not practicable for this to be completed within a reasonable time frame (within a relatively few years) while fulfilling more immediately relevant goals that would benefit the departmental mandate.

2. The analysis of the biological data base for 4WX herring has resulted in a remarkable degree of precision in the determination of key biological and life-history parameters for herring. The "recruitment ogive" in terms of length is reliable to about 0.1% and correspondingly precise estimate of the corresponding age ogive, for assessment purposes can be determined. Other biological parameters for assessment purposes are also available.

Of particular importance is the demonstration of physiological differences between the pre-recruitment and recruit sections of the population, with important implications for ecological theory. The phenomenon of "anticipatory feeding" is clearly demonstrated for the first time and implies that there are constraints on the immediate effect of environmental variability (e.g. food supply) on recruitment and year-class success.

3. The analysis with Dr. Trippel of the history of the concept of the cost of reproduction has clearly shown its lack of theoretical and empirical basis, and our possession of good evidence for the development of alternative explanations.

This is of particular importance for teleost fishes have been used in the development of the theory in recent years, because of their high fecundity and their presumed high investment in reproduction.

4. The 1972 book on cichlids continues to generate research interest. In 1991, it was identified as a main stimulus for the production of a volume on behavior.

Selected Involvements:

i. Collaborative Research -

Dr. R. Bradford, Dr. E. Trippel, Dr. M. Sinclair, research staff at the St. Andrews Station generally (including Dr. Lane). (Iles)

Dr. Gary Sharp (CIROS, Monterey) - the interaction of climate and fishing of the variability of fish stocks. (Iles)

ii. University Liaison -

Dr. Peter Reithal. University of Michigan - the ecology of cichlid zooplankton feeders in Lake Malawi; cichlid biology generally. (Iles)

Dr. Jacquie McGlade. University of Warwick, U.K. - the socio-economic factors in two European fisheries. (A visit is proposed in June 1992). (Iles)

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Dr. Iles has only a limited amount of time left in DFO. It has become evident that it will be more profitable in the short-term to produce a number of small manuscripts rather than devoting full attention to the book. It was for this reason that the priorities have been changed. Nevertheless, it is still important to emphasize the unique capacity that Dr. Iles has in producing his book and he is encouraged to continued work on it.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 130

Section: Central Shelf

Project Title: Reproductive Strategies of Marine Fish

Project Leader: Lambert, T.

Other Researchers:

Work Activity: W.A.1.1.1.2

Key Words: groundfish; fisheries ecology

1. Project Description:

A multitude of physical and biological variables can exert their influence continually or at particular stages during the early development stages of marine fish. The set of environmental variables that will affect any particular species of larva is largely decided by its parents with their choice of when and where to spawn. Limitations of the environment prohibit the simultaneous spawning of most marine fish species. Therefore, we find a succession of species spawning throughout the year in a variety of locations. Some have a protracted spawning season, others very brief; some release their eggs freely within the water column, and others attach them to the bottom or to vegetation. Assuming these tactics are adaptive and geared to ensure successful recruitment, it is of both scientific and practical interest to determine how they are adaptive and to identify any general patterns if indeed they do exist. This study investigates the trade-offs and compromises evolved by various species in exploiting available space and resources during their spawning season.

2. Long-Term Objectives:

Earlier work on mackerel and herring established that these species represent the extremes of a spectrum of spawning behaviour. The former release their eggs over a short period of time and the latter have a protracted spawning period during which they deposit discrete batches of eggs. Thus mackerel employ a 'big bang' strategy, whereas herring rely on a 'hedged bet' strategy. The present study will test hypotheses generated by this earlier work and attempt to establish the generality of these findings by expanding investigation to other species. In this context, it is also proposed to study Atlantic cod in some detail.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Substantial data has been collected during past years and a number of manuscripts are planned or are in preparation. These will be completed as time permits. If working travel is approved the collaborative manuscript on mackerel should be completed. (Lambert)

Travel to Lowestoft, U.K., allowed completion of collaborative work comparing the reproductive dynamics of eastern and western Atlantic mackerel. A first draft of a manuscript is nearing completion.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

Active research is no longer being conducted under this project, thus reporting on it is terminated with this report. Analysis of accumulated data will continue on an opportunistic basis.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -

- ii. University Liaison -

## iii. Communications -

Video with talk and fish dissection based on accumulated research on Atlantic mackerel presented to elementary school classes on the eastern shore region of N.S. (Lambert)

## iv. Contracts Administered -

## v. Other -

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Work on this project has been subsumed by activities under cod (1021) and harvesting data (9765).

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 131

Section: Computing, Gulf of Maine

Project Title: EDP Support

Project Leader: Branton, R.; Gale, J.

Other Researchers: Charlton, B.; McMillan, J.; Gale, J.; St. Andrews Computing; BIO Computing

Work Activity:

Key Words: administration; data processing

1. Project Description:

Analyze requirements, design and implement application systems and data bases. Provides consultation and assistance for staff developing their own applications and data bases. Research new techniques for analysis and information needs to keep operations up to date with developments. Provide management procedures for Divisional data bases. Provide application and data base advice to technical users and data base personnel.

2. Long-Term Objectives:

As above.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Improve computer networks and facilities, includes: Regional Operations/Science Network; Ethernet LAN for MFD BIO (paid by facilities?); Structured Wiring and LAN for STA (paid by facilities ?); establish regular Email usage; new Laser Printer at MFD/BIO (paid by branch ?); BSB VAX mini computer for HFX/DART (paid by branch ?) and; SQLnet at BIO and STA.

Regional wide area TCP/IP network is operational, providing a large number of links including: BIO Cyber, STA Vax, BIO Vax, Internet, Banyan, DFOnet, etc. (Branton, BSB Computer Committee, McMillan)

A twisted pair ethernet type local area network has been designed for MFD/BIO. A requisition for structured wiring and an ethernet concentrator has been approved and sole sourced to MT&T. Construction is expected in the 1st quarter of '92. (Branton, McMillan)

A thin wire ethernet has been installed in STA. Seven MFD/STA workstations equipped with DEC Pathworks software and connected to the network. (Gale)

All MFD computer users, BIO and STA have been exposed to electronic mail. An electronic survey indicated that most computer users were using it as required. (Branton, Charlton, McMillan, Smith)

A new laser printer was not purchased for MFD/BIO due to lack of funds. (Branton)

The plan for a BSB Vax mini was abandoned in favour of a MFD/BIO PC486 running the SCO UNIX and the Oracle RDBMS. This machine was acquired in October '91. Preliminary tests of the PC486 indicate that it is approximately 50% faster than the BIO Cyber with one user running Oracle. (Branton, Charlton)

SQLnet has been installed and is operational on the BIO Cyber. SQLnet has been installed on the STA VAX, but is non-functional due to problems with Vax Fusion TCP/IP software. This should be rectified in the 1st quarter of '92. SQLnet has been acquired for one MFD/BIO PC386, installation problems were encountered and are currently in the hands of Oracle support staff. (Branton, BSB Computer Committee, McMillan, Gale)

2. Complete conversion of systems away from NOS2, includes: archiving; ALSYS; IOP; Catch/Effort and ZIF Working Group; and ZIF data base at St. Andrews. Develop protocols to transfer IOP/ZIF/CGS data to St. Andrews. Should ZIF produce old formats?

NOS2 was removed from service June 1/91. All NOS2 users are now working with either NOS/VE, STA VAX, PCs or MACs. All assessments were completed as required. All NOS2 archive tape directories files were migrated to NOS/VE. All ASCII NOS2 archive data tapes remain as they were (except those created with /BACKUP) and are accessible from NOS/VE should they be needed. Miscellaneous archive data tapes are no longer created and have been replaced by micro computer floppy disks. (Branton, Charlton, McMillan)

NOS2 archive data tapes for Commercial landings were migrated to Archive/VE. (McMillan)

The NOS2 ALSYS program was not converted to NOS/VE but rather it was replaced by a PC version obtained from the Gulf region which was subsequently modified to handle Scotia Fundy assessments. ALSYS master creation software was converted from NOS2 to NOS/VE. Conversion of the CGS collection

to PC486/UNIX/ORACLE is underway. (Charlton, Zwanenburg)

Observer program data bases and editing software were completely redesigned and were converted from NOS2 and S2K to NOS/VE and Oracle. All COBOL software was replaced by FORTRAN 77. All 1991 data has been edited and loaded to ORACLE. (Branton, Charlton, Showell)

Catch/Effort NOS2 archive data tapes were migrated to NOS/VE and Archive/VE. All data is available through NOS/VE File Manager. All Catch/Effort SPSS programs were converted to NOS/VE. Conversion of processing software was not required for the 1991 assessments and is outstanding. (McMillan)

Development of protocols to transfer IOP/ZIF/CGS and GS data between BIO and STA is awaiting installation of SQL\*NET at STA. In the meantime a combination of flat files and Oracle Export files are being used. (Branton, Charlton, Gale, McMillan)

3. Following consensus building methods established for MFD support services in general, develop a comprehensive MFD computing strategy, includes: generalized mission statement; mainframe software requirements and support needs; desktop software requirements and support needs; system development and maintenance procedures; data base administration guidelines and; end user training curriculum. Develop procedures for maintaining new data on Divisional data bases in St. Andrews and instruct data base managers on use. (Gale)

MFD data management and computing strategies were developed through consultation with staff at both locations and approved by MFD section heads. The computing strategy was subsequently submitted for inclusion in the annual BSB computing plan. (Branton, Gale)

MFD/BIO computer user support needs were reviewed and a MFD/BIO Computer Users Group was formed. This Group meets on a monthly basis providing a focal point for computing related matters at MFD/BIO. (Branton, Charlton, McMillan)

Continued development of MFD/STA data management utilities for entry, edit, load, update, and data security/backup for the Canadian and U.S. Groundfish Surveys, Commercial landings, Commercial Samples and Pelagic Samples data bases. (Gale)

Documentation of the MFD/STA utilities and data bases was initiated with the development of DBGUIDE, a menuing system to access data base information. Development of a new Groundfish Surveys Manual is continuing. (Strong, Page, Gale)

4. Develop improved graphical and geographical analysis capability, includes: data modelling, improved Groundfish Survey data base; VAX ACON user interface improvements & PCACON development (with COGS); DecWindows/XWindows ACON (with consultant) and; SPANS pilot project.

VAX ACON was extended to include a direct interface with the Oracle Data base. (Black, Branton)

A PC ACON program was developed and a prototype released to interested staff. An improved user interface for PC and VAX versions of ACON has been developed and will be released in 1992. (Black, Branton, Zwicker)

A DECwindows Xwindows interface for ACON has not been developed due to lack of funds and expertise. (Black, Branton)

A SPANS pilot project was not conducted due to departure of scientific staff and lack of funds. (Branton, Fanning)

ORACLE procedures for extracting geo-referenced data were developed to facilitate analysis of catch data from the Groundfish Survey data base. Some experiments with alternative Groundfish Survey data models were conducted, but to date a new model has not been proposed. (Branton, Charlton, Gale, McMillan)

5. Provide end-user training and documentation, includes: SPSSX workshop; ORACLE workshop; ORACLE user's guide; ACON Workshop and; continued introduction of port technicians to the groundfish samples data entry system and to computing in general.

Oracle workshops were presented in STA, BIO and the HFX lab. (Branton, Charlton, Gale)

An Oracle User's Guide was developed and distributed to all staff. (Branton)

One additional Port Technician was brought on line. Three port technicians are now regular PC and Oracle users. (Charlton, Donaldson)

A DISSPLA Workshop was presented in STA. (Branton, Gale, Leverman)

A PC hard disk maintenance guide was developed and presented at TUNS and circulated to interested MFD Staff. (Branton)

SPSSX and ACON workshops could not be prepared due to lack of time. (Branton, McMillan)

6. Ongoing technical liaison includes: STA Computing staff; BSB Computer Committee; National DFO EDP Workshop.

Consultation with STA Computing Staff was conducted as required. A speaker phone was installed and teleconferences between MFD computing staff at BIO and STA are conducted on a regular basis. (Branton, Charlton, Gale, McMillan)

BSB computer committee meetings were attended on a regular basis, activities include: annual report, security evaluation response, and shipboard computing requirement statement, BIO open systems and Cyber replacement. (Branton)

The National DFO EDP Workshop was cancelled. (Branton)

7. Ongoing support for MFD computing equipment and software. Provide consultation on Divisional applications, Divisional data base use and common applications packages including ORACLE, APL, C, FORTRAN, graphics and SPSS. (Gale)

Equipment and software support were provided as required. New developments include the introduction of MS Windows, SCO Unix, DEC Pathworks, ARCHIVE SQL, Oracle SQL\*NET, FUSION TCP/IP, Oracle Card, Oracle PC SQL, and Oracle SQL\*Forms V3, Oracle PRO\*C. (Branton, Charlton, Gale, McMillan)

8. Participate in field trips and cruises.
9. Complete and document ORACLE to APL interface. (Gale, Gavaris)

Development of an APL to ORACLE interface was initiated but was delayed by the unavailability of Pro\*C and SQL\*NET on the VAX. A Commercial product from STSC is currently being evaluated as a possible alternative. (Gale)

10. Set up an ORACLE data base for ZIFF data. (Gale)

An Oracle data base for ZIF data and associated quality control software were developed on IML VAX and subsequently migrated to BIO Cyber. Sample sets of data have been processed through the quality control system and loaded to the data base. A Zonal Workshop was conducted to review quality of ZIF data as produced by Statistics. (Branton, McMillan)

An Oracle data base for ZIF data was implemented on STA VAX using same definitions as IML and BIO versions. A CATCH program was developed with interactive selection to create summarized Landings reports with cross-references to Commercial Samples and Length and Age Keys used in APL assessment workspaces. The Catch program works for the both U.S. and Canadian data bases. (Gale)

11. Improve computer networks and facilities, includes: Regional Operations/Science Network; Ethernet LAN for MFD BIO (paid by facilities?); Structured Wiring and LAN for STA (paid by facilities?); establish regular Email usage; new Laser Printer at MFD/BIO (paid by branch?); BSB VAX mini computer for HFX/DART (paid by branch?) and; SQLnet at BIO and STA.

Installed SQL\*NET on the VAX, but is non-functional because it requires a newer version of FUSION TCP/IP software. This should be rectified shortly. (Gale)

Installed and set up the default environments for PathWorks communications software for both the Vax (Server) and PCs (Client). Installed and performed trouble-shooting for PC ethernet controller boards for new acquired DECstation PCs. Assisted users with the use and modifications of Pathworks. (Gale)

Set up default environments and assisted users with newly acquired VT1200 X-terminals. (Gale)

12. Complete conversion of systems away from NOS2, includes: archiving; ALSYS; IOP; Catch/Effort and ZIF Working Group; and ZIF data base at St. Andrews. Develop protocols to transfer IOP/ZIF/CGS data to St. Andrews. Should ZIF produce old formats?
13. Following consensus building methods established for MFD support services in general, develop a comprehensive MFD computing strategy, includes: generalized mission statement; mainframe software requirements and support needs; desktop software requirements and support needs; system development and maintenance procedures; data base administration guidelines and; end user training curriculum. Develop procedures for maintaining new data on Divisional data bases in St. Andrews and instruct data base managers on use. (Gale)

MFD data management and computing strategies were developed through consultation with staff at both locations and approved by MFD Section Heads. The computing strategy was subsequently submitted for inclusion in the BSB computing plan. (Branton, Gale)

Continued development of data management utilities for entry, edit, load, update, and data security/backup for the Canadian and U.S. Groundfish Surveys, commercial samples and pelagic samples data bases. (Gale)

Documentation of the utilities and data bases was initiated with the development of DBGUIDE, a menuing system to access data base information. Development of a new Groundfish Surveys Manual is continuing. (Strong, Page, Gale)

14. Develop improved graphical and geographical analysis capability, includes: data modelling, improved Groundfish Survey data base; VAX ACON user interface improvements & PCACON development (with COGS); DecWindows/XWindows ACON (with consultant) and; SPANS pilot project.

Vax ACON was extended to include a direct interface with ORACLE. (Black)

15. Provide end-user training and documentation, includes: SPSSX workshop; ORACLE workshop; ORACLE user's guide; ACON Workshop and; continued introduction of port technicians to the groundfish samples data entry system and to computing in general.

ORACLE workshop was presented in St. Andrews (Branton, Gale). A DISSPLA Workshop was presented in St. Andrews (Leverman, Branton, Gale).

16. Ongoing technical liaison includes: STA Computing staff; BSB Computer Committee; National DFO EDP Workshop.

Consultation with BIO computing staff was conducted as required. Teleconferences between MFD

computing staff at BIO and St. Andrews are conducted on a regular basis.

17. Ongoing support for MFD computing equipment and software. Provide consultation on Divisional applications, Divisional data base use and common applications packages including ORACLE, APL, C, FORTRAN, graphics and SPSS. (Gale)

Equipment and software support were provided as required. New developments include the introduction of DEC PathWorks PC network, X-Windows terminals, Archive\*SQL, ORACLE 6.0 and SQL\*FORMS 3.0, FUSION TCP/IP, SQL\*NET and Pro\*C (Gale).

18. Participate in field trips and cruises.

Scotia Shelf Groundfish Summer Survey - July 91. (Gale)

19. Complete and document ORACLE to APL interface. (Gale, Gavaris)

Development of an APL to ORACLE interface was initiated but was delayed by the unavailability of Pro\*C and SQL\*NET on the VAX. A commercial product from STSC is currently being evaluated as a possible alternative. (Gale)

20. Set up an ORACLE data base for ZIFF data. (Gale)

An ORACLE data base for ZIF was created using same definitions as per IML and BIO versions. A CATCH program was developed with interactive selection to create summarized landings reports with cross-references to commercial samples and length and age keys used in APL assessment workspaces. The catch program works for both U.S. and Canadian data bases.

#### 4. Additional Accomplishments:

Installed ORACLE 6.0 and two upgrades and performed the role of DBA; Evaluated Archive\*SQL for archiving ORACLE data and system files; Created pelagic samples data base including modifications to the Edit System. Initiated development of pelagic samples age and length frequency online entry; Created juvenile surveys data base for Koeller with several load utilities for various input formats; Created Station selection program in APL for Scotian Shelf, eastern Shelf and Georges Bank; Converted existing SQL\*FORMS 23 systems to the new version SQL\*FORMS30 to eliminate user and development overhead; Created DBGUIDE menuing system to provide online documentation and easy access to Divisional data bases. (Gale)

#### 5. Goals/Expected Outputs for 1992:

1. Improve MFD/BIO local area network and associated computing facilities. Includes: ethernet LAN to all MFD/BIO and CAFSAC workstations; evaluate need for ethernet router; PC/NFS (network file system) licences for all MFD/BIO and CAFSAC workstations; MSWindows, SQL\*NET and ORACLE Card for selected workstations (i.e. all Computer Section workstations and one each for Central Shelf and Southern Shelf sections); multi-user access to PC486 UNIX workstation (starting with Computer Section Data Base conversion projects); PC486 SQL\*net access to STA VAX and Cyber Replacement; expanded and air-conditioned computer room; and new laser and/or colour printer(s). (Branton, Charlton, McMillan)
2. Convert MFD/BIO ORACLE data base systems away from the Cyber NOS/VE platform. Includes: Commercial Samples, Commercial Landings, Groundfish Surveys and the Observer Program. Alternative target platforms in order of preference are: MFD/BIO PC486 UNIX; single user PC386 DOS; and the yet to be defined Cyber replacement. Every reasonable effort will be made to accommodate all collection/editing systems on the PC486 and only progress to other systems if absolutely necessary. The capabilities of the PC486 will require continued exploration may have to be upgraded (e.g. archive/backup hardware/software, more memory, more disk, and faster CPU). A second PC486 for ad-hoc analysis and file serving, leaving the first for collection/editing type work only, must also be considered. (Branton, Charlton, McMillan)
3. Continue support and development of the Commercial Samples data system and continued expansion and improvement of services to field staff. Includes: conversion away from Cyber NOS/VE; end-user access to the Oracle data base; PC Alsys software support and user training; commercial catch at age data products; length frequency data products; and all Port Technicians on line. (Charlton, Zwanenburg)
4. Continue support and development of Commercial Landings data system. Includes: ZIF working group; ZIF production runs using old (i.e. flat file) system for 1992 assessments; Oracle ZIF test runs for 1992 assessments; conversion of ORACLE ZIF away from Cyber NOS/VE; and end-user access to the ZIF Oracle data base; and more timely access to IQ data bases; and ZIF Verification Workshop in preparation for 1993 assessments. (Annand, Branton, McMillan, ZIF Working Group)
5. Continue support and development of Observer Program data system. Includes: review and continued development of the Cyber NOS/VE system; end-user access to the Oracle tables; interfacing to PC ALSYS; conversion away from Cyber NOS/VE; and development of various standardized data products. (Branton, Showell)
6. Continue support and development of Groundfish Survey data system. Includes: maintain copy of data base at BIO for end-user access; access to STA via SQL\*NET; review of data base structure; and development of various standardized data products. (Branton, McMillan, Gale)
7. Continue support for and involvement in MFD Computer User Group. This includes: selecting, recommending and supporting a PC statistical graphic standard; Structured Query Language Interest group; development and support of MFD/BIO Hardware/Software inventory data base; and experiments with INFOCUS mapping system. (Branton, Charlton, McMillan, MFD Computer User Group)
8. Improve graphical and geographical analysis capability. Includes: production version of PC

ACON; PC486 UNIX version of ACON; and Oracle Data Base links. (Branton, Black)

9. Improve MFD/BIO administrative tracking systems. Includes: Paradox PC data base. (McMillan, O'Boyle, Stobo)
10. Ongoing external technical liaisons. These include: MFD/STA computing staff; BSB Computer Committee, Scotia Fundy Informatics Working Committee and various subcommittees; BIO Computer Center; and STA Computer Centre. (Branton, Charlton, McMillan)
11. Participate in field trips and cruises. (Branton, Charlton, McMillan)
12. Complete development of Pelagic Edit System online age and length frequency data entry. (Gale)
13. Revise the groundfish edit system and document as part of the Groundfish Surveys Manual. (Gale)
14. Continue the development of an APL to ORACLE interface and/or investigate STSC option. (Gale)
15. Develop a larval herring data base and utilities. (Gale)
16. Revise the ZIF data base with the final structure as set by the ZIFF working group. (Gale)
17. Monitor the performance and tune all major Divisional data bases. (Gale)
18. Continue development and documentation of data management utilities for updating and maintaining all production data bases. Canadian and U.S. groundfish surveys, commercial landings and commercial samples data bases. Also, pelagic samples and new larval data bases. Assist the various data base managers with effective use of new utilities. (Gale)
19. Investigate real time data entry and editing at sea for the groundfish surveys. (Gale)
20. Continue to instruct technical users and data base personnel and provide application and data base advice and assistance. (Gale)
21. Continue to provide technical assistance and advice for the operation of the PathWorks and X-Windows environments. (Gale)
22. Continue maintenance of major Divisional applications including STRAP and CATCH. (Gale)
23. Expand list of drivers available for ACON. (Black, Gale)

#### 6. Background:

##### Highlights:

Conversion away from NOS2 (Branton, Charlton, McMillan); implementation of Oracle data bases (Branton, Charlton, Gale, McMillan, Branton); implementation of a regional wide area ethernet (Branton, BSB Computer Committee); and acquisition of PC486 Oracle Development Workstation (Charlton, Branton).

##### Selected Involvements:

##### i. Collaborative Research -

##### ii. University Liaison -

PC Hard Disk Maintenance Seminar at the Technical University of Nova Scotia. (Branton)

##### iii. Communications -

##### iv. Contracts Administered -

ZIF Catch Effort Data Base design and development. (Oracle Canada, McMillan, Branton)

ZIF Catch Effort Quality Control. (Software Kinetics, McMillan, Branton)

PC ACON Graphics Program development. (Zwicker, Gerry Black, Branton)

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

SQL\*PLUS for Cyber and VAX Users (Branton)

PC Hard Disk Maintenance (Branton)

ZIF Verification Workshop Report (Branton, McMillan)

iv. Popular and Miscellaneous -

8. Review and Evaluation:

It cannot be overemphasized that the productivity of the EDP group has been outstanding, this in the face of so many conflicting demands. During the coming year, there will be a concerted effort to consolidate computing at BIO on hardware separate from the CYBER. This will facilitate the management of EDP in the Division and particularly enhance BIO/STABS data interchange.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 132

Section: Southern Shelf

Project Title: Statistical Research and Collaborative Studies

Project Leader: Smith, S.

Other Researchers: Gavaris, S.; Bowen, D.; Stobo, W.

Work Activity: W.A.1.1.1.2

Key Words: survey research; statistics; sampling; experimental design

1. Project Description:

Evaluate current trawl and acoustic survey designs to optimize efficiency and usefulness. Investigate alternative designs and models which incorporate distributional properties of the marine resources being surveyed. Collaborate with other researchers on projects requiring experimental designs and/or statistical models.

2. Long-Term Objectives:

Develop survey designs and methodology which will provide more accurate and precise abundance indices and other measures useful in the stock assessment of groundfish and pelagic species. Encourage the use of statistical methods where appropriate for the design and analysis of research experiments.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Relationships between environment and trawl survey indices: a) given results to date on the existence of relationships between environment and catches from trawl surveys we need to explore the implications of such relationships. Using what we have learned from our studies of 4VSW cod we intend to consider two major questions, i.e. i) How can these relationships affect trends in trawl survey indices?; and ii) How do we incorporate this kind of information into our estimates of abundance and into our stock assessments? We will use these questions to construct a framework to identify gaps in the current research program and future directions (with Perry); b) continue to participate in PCS AFAP project to set up a regional hydrographic data base which brings together data from PCS, BSB and other sources (e.g. National Sea); c) continue to investigate concerning the relationships between hydrographic and other environmental variables and catches of various ages and species of fish in trawl survey catches. This will involve comparing the results of analyses of data from the English Groundfish Survey with findings to date from the Scotian Shelf Surveys. (Smith)

a) In progress. Dr. Perry has taken a position with DFO in Nanaimo, B.C. and travel for Mr. Smith to work with Dr. Perry was not funded. b) In progress. Project is still in data identification and data base structure phase. c) In progress. More methodology has been developed to investigate these relationships and a manuscript is in preparation.

2. Evaluation of Survey designs: a) publish paper on restratification study (with Gavaris); b) evaluate potential bias resulting from various optimum allocation procedures available in literature (with G. Jolly); c) evaluate the properties (design-based bias, consistency and precision) of efficiency estimates used to compare stratified random with simple random designs (with M. Nicholson). (Smith)

a) Paper has been submitted for publication. Still waiting on referees' reports. Survey design evaluated for Scotian Shelf surveys of all cod stocks, haddock stocks and pollock stock completed and presented to groundfish subcommittee of CAFSAC. Paper published as a CAFSAC Research Document. Presented paper (with Gavaris) on using resampling methods to incorporate uncertainty from surveys into estimates of projected catch to "Risk Evaluation and Biological Reference Points for Fisheries Management", November 19-22, 1991 in Halifax. b) Preliminary results were presented to the March meeting of the SSS Subcommittee meeting of CAFSAC. Work is ongoing. c) In progress. Results to be presented at the ICES Workshop on Analysis of Trawl Survey Data, June 3-6, 1992 in Woods Hole, MA.

3. Comparison of Survey designs: Recent investigations by the ICES Methods Working Group have suggested that fixed station surveys are more precise than stratified random surveys. These findings need to be evaluated in the context of our own use of the latter design. Comparisons will be carried out between the Scotian Shelf Surveys and the English Groundfish Survey to investigate strengths and weaknesses of each design (with M. Nicholson).

In progress. Results to be presented at the ICES Workshop on Analysis of Trawl Survey Data, June 3-6, 1992 in Woods Hole, MA.

4. Complete analysis of cod length-weight data. There are three aspects of this project which need to be completed: a) literature review and investigation of the use of error-in-variable linear

models in biology in general and for length-weight data in particular completed. Manuscript needs to be polished; b) study of the effects of sample design on parameter estimates for length-weight relationships from groundfish survey to be completed; and c) a study into the use of length-weight relationships for cod as indicators of the different cod stocks to be initiated (with L.P. Fanning and G. Chouinard, Gulf Region). (Smith)

a-c) No progress on this project. Mr. Fanning has left the Division. Project given lower priority due to workload of projects 1, 2 & 6.

5. Collaborative Studies. These projects are grouped together because they all require the development of new statistical methods or the modification of standard methodology: a) Publication of the Domoic acid study (with Subba Rao); b) Continue work on modelling eutrophication (with Subba Rao); c) Complete paper on harbour seal pup growth (with Stobo); d) Complete seal worm analysis and coauthor paper (with Bowen with Dalhousie Researchers). (Smith)

a) Analysis of data completed. Manuscript in preparation. b) No progress. Low priority because of project 1, 2 & 6. c) Analysis of data completed. Manuscript in preparation. d) No longer involved with this project.

6. Plan and chair meetings of the Statistics, Sampling and Surveys (SSS) Subcommittee of CAFSAC. (Note Smith's appointment as chairperson of this subcommittee ends as of June 1991.) Specifically organize and chair meeting of Subcommittee in the Winter of 1991 and co-organize and co-chair a special symposium/workshop for the subcommittee in the Fall of 1991. (Smith)

Chaired meeting of SSS subcommittee Dartmouth, N.S., March 26-28, 1991. Report delivered to CAFSAC Steering Committee. The CAFSAC workshop on "Risk Evaluation and Biological Reference Points for Fisheries Management" was organized and convened Nov.19-22, 1991 in Halifax. This workshop was attended by 65 scientists from Canada, U.S., Europe, Africa, New Zealand and Australia. The workshop was a major success and Mr. Smith will take the lead in editing a peer-reviewed publication of the proceedings.

7. Initiate Ph.D. studies in the Department of Mathematics and Statistics, Dalhousie University in September 1991 on a part-time basis. The thesis topic will be on the recent developments in Likelihood Theory in Statistics with emphasis on the models which contain so-called "nuisance" or "incidental" parameters, e.g. Poisson models where the variance exceeds the mean. These kind of models arise quite often in the analysis of fisheries data and are not always amenable to analysis using standard methods. In particular, some use of these kind of models have been in 1990 goal #'s 1 a-c, 2 and will be important for ongoing work on these goals in 1991. Formal training will be required to take full advantage of the developments in this field. (Smith)

No progress. This project was not funded.

#### 4. Additional Accomplishments:

Redesigned the sample design to monitor size of scallops being landed to be more defensible and help develop the basis of a new enforcement system for the scallop fishery. This new system is to be based on contractual agreements between the industry and the government; Published book review of The American Fisheries Society Symposium Series on stock assessment methods; Modelled the spatial distribution of scallops on Georges Bank. In this study it was shown that the distribution of scallops followed a Poisson model within sediment type with the scallops exhibiting a preference for gravel sediment types; Invited organizer and chair for session "Statistics and Public Policy: Some experiences in the fields of environmental and natural resource management." American Statistical Association Annual Meeting, Atlanta Georgia; Invited (and funded) participant in three Northern Cod Science Program Workshops (St. John's, NFLD): (i) Oceanography Workshop, January 16-17., (ii) Trawl Gear Mensuration Workshop, March 18-19., (iii) Acoustics Methods for Demersal Species Workshop, August 27-29., & (iv) Invited speaker. Acoustic Methods for Demersal Species: A Northern Cod Science Program Workshop, St. John's, NFLD. "Basic principles for the design of acoustic surveys for pelagic fish stocks in the CAFSAC management area." (Smith)

#### 5. Goals/Expected Outputs for 1992:

1. Relationships between environment and trawl survey indices: a) given results to date on the existence of relationships between environment and catches from trawl surveys we need to explore the implications of such relationships. Using what we have learned from our studies of 4VsW cod we intend to consider two major questions, i.e. i) How can these relationships affect trends in trawl survey indices?; and ii) How do we incorporate this kind of information into our estimates of abundance and into our stock assessments? We will use these questions to construct a framework to identify gaps in the current research program and future directions (with Perry and Page); b) continue to participate in PCS AFAP project to set up a regional hydrographic data base which brings together data from PCS, BSB and other sources (e.g. National Sea); c) continue to investigate concerning the relationships between hydrographic and other environmental variables and catches of various ages and species of fish in trawl survey catches. This will involve comparing the results of analyses of data from the English Groundfish Survey with findings to date from the Scotian Shelf Surveys. Results to be presented at ICES Bottom Trawl Workshop, Woods Hole (June 1992). (Smith, with Perry)
2. Evaluation of Survey designs: a) publish paper on restratification study (with S. Gavaris); b) evaluate potential bias resulting from various optimum allocation procedures available in literature (with G. Jolly); c) evaluate the properties (design-based bias, consistency and precision) of efficiency estimates used to compare stratified random with simple random designs (with M. Nicholson, MAFF, Lowestoft). (Smith)
3. Comparison of Survey designs: Recent investigations by the ICES Methods Working Group have suggested that fixed station surveys are more precise than stratified random surveys. These findings need to be evaluated in the context of our own use of the latter design. Comparisons will be carried out between the Scotian Shelf Surveys and the English Groundfish Survey to investigate strengths and weaknesses of each design. Results to be presented at ICES Bottom

Trawl Workshop, Woods Hole (June 1992) (with M. Nicholson, MAFF, Lowestoft). (Smith)

4. Collaborative Studies. These projects are grouped together because they all require the development of new statistical methods or the modification of standard methodology: a) Publication of the Domoic acid study (with Subba Rao); b) Continue work on modelling eutrophication (with Subba Rao); c) Complete paper on harbour seal pup growth (with Stobo). (Smith)
  5. CAFSAC Workshop. a) Edit and publish the proceedings in the Special Publication series of the Canadian Journal of Fisheries and Aquatic Science; b) Prepare a presentation of proceedings for Regional Director General meeting in Feb., 1992. (Smith)
  6. Assistant Editor, ICES Journal of Marine Science. Carry out editorial duties. (Smith)
6. Background:

Highlights:

Appointed as Assistant Editor (Statistics and Stock Assessments) for The ICES Journal of Marine Science (formerly Journal du Conseil) for a 3-year term (1992-1994); CAFSAC Workshop on "Risk Evaluation and Biological Reference Points for Fisheries Management", November 19-22, 1991 in Halifax. (Smith)

Selected Involvements:

i. Collaborative Research -

Survey research with S. Gavaris (MFD), G. Jolly (Edinburgh), M. Nicholson (MAFF), I. Perry (DFO-PBS); Spatial analysis with G. Thouzeau (BAFD and IFREMER) and G. Robert (BAFD); Sample design research with G. Robert (BAFD). (Smith)

ii. University Liaison -

Graduate student committee member Dalhousie. (Smith)

iii. Communications -

TV interview for Cable 10. (Smith)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Smith, S.J., R.I. Perry, and L.P. Fanning. 1991. Relationships between water mass characteristics and estimates of fish population abundance from trawl surveys. Environmental Monitoring and Assessment 17: 227-245.

Thouzeau, G., G. Robert, and S.J. Smith. 1991. Spatial variability in distribution and growth of juvenile sea scallops, *Placopecten magellanicus* (Gmelin), on eastern Georges Bank (Northwest Atlantic). Marine Ecology - Progress Series 74: 205-218.

Waiwood, K.G., S.J. Smith, and M.R. Petersen. 1991. Feeding of cod (*Gadus morhua*) at low temperatures. Can. J. Fish. Aquat. Sci. 48: 824-831.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Smith, S.J. 1991. Assessing the efficiency of the groundfish survey design for the Scotian Shelf summer surveys -- 1980-1990. CAFSAC Res. Doc. 91/39: 15p.

iv. Popular and Miscellaneous -

Smith, S.J. 1991. Book review of "Mathematical Analysis of Fish Stock Dynamics", E.F. Edwards and B.A. Megrey (Eds.). Transactions of the American Fisheries Society 120: 669-670.

8. Review and Evaluation:

This project is essential to the quantitative basis for stock assessment in MFD. The breadth of projects is indicative of the work load involved and thus the high level of productivity is particularly commendable. Of note is the convening of the Risk workshop. This has been long overdue and was a great success. The challenge will now be to turn the theory into reality. Overall, this project is proceeding well.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 134

Section: Southern Shelf

Project Title: Stock Structure Studies

Project Leader: Zwanenburg, K.

Other Researchers: Lambert, T.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; Subarea 4; ESP; distribution; stock structure; genetics

1. Project Description:

Management of the Scotia-Fundy groundfish resources depends upon knowing the spatial and temporal boundaries of the unit populations which make up these harvestable resources, and the degree to which they interact. Recent assessments of these resources have pointed out a number of cases where our understanding of these parameters is inadequate (cod in 4T and 4Vn, cod in 4VsW, haddock in 4TVW, and redfish in 4RST/4VWX/3P). Independent reviews of stock assessment procedures have indicated that their efficacy is limited by a lack of understanding of basic biological parameters, including population composition and boundaries, rather than the adequacy of the mathematical constructs employed in modelling them. Developments in statistical, genetic, and biochemical analytical techniques since present management units were defined suggests their use in refining these definitions. Improved understanding of stock boundaries and inter-relationships will allow for more meaningful definition of management units.

2. Long-Term Objectives:

To investigate the spatial, temporal, and genetic boundaries of groundfish populations using the most appropriate methodologies available. This work will focus on refining present stock boundaries and on investigating the genetic inter-relationships between and within these boundaries.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

- Using ships of opportunity, continue collecting ovaries from cod in pre-spawning aggregations belonging to putative populations inhabiting 4T, 4Vn, 4Vs, and 4W. To extract mitochondrial DNA from these tissues, and conduct restriction endonuclease analysis of genotypic variation. This objective is a contribution to the Eastern Shelf Program. (Zwanenburg)

Purified mitochondrial DNA is now available from a number of locations within the 4TVW area both from putative spring and fall spawners. A limited number of samples have been analyzed using restriction endonuclease. Results thus far are insufficient to draw conclusions regarding population structure.

- Continue the literature and fisherman survey to determine the location and timing of cod spawning on the eastern Scotian Shelf. This objective is a contribution to the Eastern Shelf Program. (Zwanenburg with Fanning).

This initiative was continued concomitant to the collections of ovaries from pre-spawning aggregations as noted above. The survey will continue until all major aggregations have been determined and sampled.

- To complete the processing of redfish mitochondrial DNA. To initiate the analysis of these data and determine the efficacy of their use in species and population differentiation. (Zwanenburg, Bentzen)

Sufficient mitochondrial DNA was extracted from 120 redfish split approximately equally between two putative species (mentella fasciatus) independently classified on the basis of extrinsic gasbladder musculature. The results of these analysis were presented at the International Symposium on Biochemical Genetics and Taxonomy of Fish at Queens University in Belfast Northern Ireland (Zwanenburg, K.C.T., P. Bentzen, D. Power, L.J. Bryden, and J.M. Wright. 1991. Biochemical systematics of Northwest Atlantic redfishes (Sebastes)), presented at the Fisheries Society of the British Isles, International Symposium on Biochemical Genetics and Taxonomy of Fish, Queens University of Belfast, Belfast, Northern Ireland, July 22-26, 1991., and indicated the level of variation redfish in redfish mtDNA is very low, that the molecule is large and varies in size increments of approximately 300 base pairs between individuals. These results did not indicate any systematic difference between mentella and fasciatus. Work on this problem is being continued as a joint project with Dr. Paul Bentzen at the Marine Gene Probe Lab.

- To use existing ongoing surveys, specifically the January Gulf survey, and the March 4VsW cod survey to collect an additional number of redfish ovaries to increase the sample size. (Zwanenburg)

Several hundred additional specimens have been collected including tissues from Helicolenus dactylopterus and Sebastes aleutianus (collected by colleagues from the Pacific Biological Station) to act as outgroups. These specimens will be used to root the phylogenetic trees produced for Northwest Atlantic Sebastes. Samples of S. Fasciatus and S. Mentella were also collected during the Subarea 3 redfish surveys conducted by the Newfoundland Region. These samples were identified to species using gasbladder muscle morphology at the time of collection and will be used in a continuing study of Sebastes taxonomy and population structure.

#### 4. Additional Accomplishments:

1. Refereed a number of papers dealing with mitochondrial DNA analysis and population structure studies. (Zwanenburg)
2. Reviewed 5 science subvention proposals dealing with stock differentiation problems and methodologies. (Zwanenburg)
3. Acted as scientific authority to a subvention grant granted to J.M. Wright and P. Bentzen to investigate redfish biochemical taxonomy population structure. (Zwanenburg)

#### 5. Goals/Expected Outputs for 1992:

1. To continue the analyses of cod mitochondrial DNA from putative populations in 4TVW with the aim of determining the efficacy of this approach in population discrimination/interaction. To derive maximum potential benefit from this project it is necessary to use the greatest number of available genetic probes/markers. It is proposed that this project become closely associated with collaborative effort and cod population structure with the Newfoundland Region, and the Marine Gene Probe Laboratory and use the facilities of that laboratory to allow for expanded analyses. (Zwanenburg)
2. Prepare a manuscript documenting the results of restriction endonuclease analysis of redfish mitochondrial DNA. (Zwanenburg, Bentzen)
3. Continue the study of redfish taxonomic and population inter-relationship using analysis of rapidly evolving DNA segments including satellite sequences in the nuclear genome and a 300 base pair repeat sequence that was identified during the work on mitochondrial DNA sequence variation. (Zwanenburg, Bentzen, Wright)

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

Collaboration on redfish taxonomy/population structure with Drs. Paul Bentzen and Jonathan Wright, Marine Gene Probe Laboratory, Dalhousie University. (Zwanenburg)

##### ii. University Liaison -

##### iii. Communications -

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

##### iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

It is evident that stock differentiation by genetic markers is a complex process. Generally the results reveal evolutionary relationships but do not allow for the unequivocal classification to spawning origins of fish taken from a mixed population. These results reflect the true complexity of population interactions. The challenge for this line of research will be to incorporate these results into stock assessment/management framework.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 1350

Section: Gulf of Maine

Project Title: Dynamics of Recruitment Processes for Gulf of Maine Gadids

Project Leader: Trippel, E.

Other Researchers: Neilson, J.; Buzeta, M.; Annand, C.; Van Eeckhaute, L.; Page, F.; Iles, D.; Brown, L.; Peterson, R. (AIFD); Morgan, J. (DFO, St. John's)

Work Activity: W.A.1.1.1.7

Key Words: research; life history; harvesting; resource management; recruitment; dynamics; gadids

1. Project Description:

Research on the biology and life history characteristics of gadids and of environmental influences which impact on recruitment dynamics.

2. Long-Term Objectives:

Provide advice on suitable harvesting strategies and fisheries management practices by incorporating knowledge and understanding gained about stock reproductive potential and recruitment dynamics. To develop an accurate estimate of stock reproductive potential which includes gamete quality, age and size of spawner, reproductive output, fertilization and hatching success.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. This project will assess the effect of parent size on offspring survival and quality in gadids. The experimental design for cod consists of fertilizing eggs from small females with sperm of small males, fertilizing eggs of large females with sperm of large males, and conducting fertilizations between small and large parents. Small fish are about 40 cm long and are reaching their first year of reproductive activity, whereas large fish are >100 cm long and are repeat spawners. Fertilization success, hatching success, egg size, larval size and larval survival will be assessed. The experiment will be repeated using the same adult pairings each year for five years. The information gained will be used to identify whether a decrease in viability of sex products occurs with ageing and whether fish that develop high-quality sex products should be subject to lower exploitation rates than those developing low-quality sex products. (Trippel, Neilson)

An experiment based on this long-term objective was conducted and a manuscript submitted to Can. J. Fish. Aquat. Sci. in Aug./91 entitled 'Fertility and sperm quality of virgin and repeat-spawning Atlantic cod (*Gadus morhua*) and their influence on hatching success'. Findings have also been published in a Special Publication of the European Aquaculture Society and will be presented as a Poster at CCFPR'92 in Halifax.

2. Using survey results, the dynamics of haddock maturation will be investigated. Maturity ogives will be examined and the relationship of length and age to maturation will be considered. Maturity stage determinations at sea will be compared to histological results. (Trippel, Van Eeckhaute, Annand, Gavaris)

Using maturity data, age and length-based maturity ogives were constructed for cod, haddock and pollock using spring survey data from 4Vn, 4Vs, 4W, 4X, and 5Z from 1980-1991. A cooperative project was initiated with Dr. S. Clark (Woods Hole) to analyze long-term trends in Georges Bank haddock maturity from 1968-present.

3. Completion of the otolith element study, presentation at the 15th Annual Larval Fish Conference, and publication. (Neilson et al.)

The study has been completed, and results indicate that within-sample variation is higher than was previously appreciated. Results from the electron microprobe were compared with elemental analyses obtained, through collaboration with PCSB, using both AAS and ICP-MS techniques. A primary publication will be submitted in the first quarter of 1992 documenting these results.

4. Additional Accomplishments:

1. Conducted experimental work on Grand Banks, Newfoundland, to examine if fertilization success of Atlantic cod is age dependent. (Trippel; Morgan (St. John's, Nfld.))
2. A paper was completed for publication on comparing six methods commonly used by fish population ecologists to estimate age and size at sexual maturity. (Trippel)

3. A manuscript was prepared which was aimed towards conserving population fecundity of the ~2000 exploited lake trout populations in Ontario (accepted for publication in N. Am. J. Fish. Manag.). (Trippel)
  4. A paper was completed for publication which examined the potential impact of climate warming on whitefish (Coregonus lavaretus) in Germany's largest lake. (Trippel)
  5. Invited as an external panel member to review scientific research proposals for NOAA's Global and Climate Change Program (Marine Ecosystem Response Program), Washington, D.C. (June/91). (Trippel)
  6. Member of ICES Cod and Climate Change (CCC) Working Group. (Trippel)
  7. Appointed as Scotia-Fundy Region representative of DFO's Fisheries In A Changing Climate (FICC) Working Group. (Trippel)
  8. Served as Chairman of the St. Andrews Library Committee. (Trippel)
5. Goals/Expected Outputs for 1992:
1. Examine relationships between age of parents, percent hatch, and survival rate during the pre-exogenous larval feeding phase of Atlantic cod. This project is planned for Jan.-Apr./93 where 1992 is the set-up year. (Trippel, Peterson)
  2. Develop a method of estimating female reproductive output of cod which accounts for protracted spawning in this species. Specifically, collect ovaries and somatic tissue of Georges Bank and assess somatic protein reserves and oocyte size profiles. (Trippel, Buzeta, Brown)
  3. Examine published evidence on the energetic trade off of gonad and soma development in fishes with a critical review of the term 'cost of reproduction'. (Trippel, Iles)
  4. Investigate data availability to determine if cod spawning stock biomass is associated with egg density on Georges Bank. (Trippel, Page)
  5. From experiments conducted during a cruise in May, 1991, evaluate and prepare a manuscript on the fertilization success of different age groups of male cod. (Trippel; Morgan (St. John's, Nfld.))
  6. In co-operation with U.S. colleagues, determine the long-term changes in haddock age and size at maturity of Georges Bank (1968-present). (Trippel, Van Eeckhaute, Annand)
  7. Continue to be involved in climate change issues by involvement in (ICES Cod and Climate Change (CCC), by participation as Scotia-Fundy representative for DFO's Fisheries In a Changing Climate (FICC) and by preparing a manuscript for the International Symposium on Climate Change and Northern Fish Populations, Victoria, B.C., Oct. 13-16, 1992. (Trippel)
  8. Serve as Chairman of the St. Andrews Library Committee. (Trippel)
  9. Act as Thesis Advisor and DFO Science Subvention Liaison Officer for R. Rangeley. (Neilson, Trippel)
  10. Write-up of larval cod condition study. (Neilson, Perry)
  11. Maintenance of larval fish rearing facility and adult broodstock. (Perley, Sampson, Trippel)
6. Background:
- Highlights:
- Initiation of a long-term program to examine fertility of precocious and non-precocious gadids.
- Involvement in climate change issues and working groups.
- Selected Involvements:
- i. Collaborative Research -  
S. Clark (Woods Hole), L. Jorgensen (University of Trondheim, Norway), J. Morgan and J. Baird (St. John's, Newfoundland).
  - ii. University Liaison -  
M. Ferguson (Guelph), T. Rand (Acadia), J. Parsons (Dalhousie)
  - iii. Communications -  
Participation in FINS'91 and meeting with cod fishermen on Grand Manan and in St. George - CBC interview (Fredericton).
  - iv. Contracts Administered -
  - v. Other -
7. Publications:

## i. Primary -

Trippel, E.A., and H.H. Harvey. 1991. Comparison of methods used to estimate age and length of fishes at sexual maturity using populations of white sucker (Catostomus commersoni). Can. J. Fish. Aquat. Sci. 48: 1446-1459.

Trippel, E.A., R. Eckmann, and J. Hartmann. 1991. Potential effects of global warming on whitefish in Lake Constance, Germany. Ambio 20: 226-231.

Logan, C., E.A. Trippel, and F.W.H. Beamish. 1991. Thermal stratification and benthic foraging patterns of white sucker. Hydrobiologia 213: 125-132.

## ii. Interpretive Scientific -

Trippel, E.A., P. Perley, and J.D. Neilson. 1991. Spermatocrit and sperm swimming speed do not correlate with fertilization success in Atlantic cod (Gadus morhua). Larvi '91 - Fish & Crustacean Larviculture Symposium 15: 227-229.

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

This is the first year of this project and it is showing signs of being a very valuable contribution to the MFD program. It will be important to keep the research focused on particular subject areas as the field is complex and can lead to the following of side issues.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9765

Section: Central Shelf

Project Title: Groundfish Ecosystem - Harvesting Data

Project Leader: O'Boyle, R.

Other Researchers: Lambert, T.; Hurley, P.; Hunt, J.; Buzeta, M.; Trippel, E.; Van Eeckhaute, L.; Neilson, J.; Gavaris, S.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; cod; research

1. Project Description:

The forerunner of this new project was Project #1330: Cooperative Science-Industry Groundfish Research and Communication.

This program expands the scope of interaction between science and industry beyond the 'index' fishing concept. The emphasis here will be on biological studies not directly tied to the assessment process. Joint work at this level will foster a new appreciation for the abilities of both groups in the study of fish biology. As such it will serve as a valuable medium for communications and education.

2. Long-Term Objectives:

Research carried on under this project will provide a good biological basis upon which to establish sound assessment of groundfish stocks. During the course of these studies, it is anticipated that by assisting in the set up of the programme and in the subsequent collection of data, fishermen will gain a better understanding of the research process.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. In consultation with fishermen, establish four or five inshore stations in Subdivision 4Vn and begin monitoring cod stocks on a bimonthly basis. (Lambert)

Regular groundfish sampling has been implemented in areas advised by fishermen as being trawlable. Seven cruises between April and November were carried out roughly monthly, and some fixed stations have been established in locations of particular interest; for example at one site where young-of-the-year and one-year old cod are found consistently.

2. Carry out ichthyoplankton survey to assess degree of fall-spawning of cod along inshore coast of eastern Nova Scotia. (Lambert)

Ichthyoplankton tows were taken in Bras d'Or Lake and on Smokey Bank in Sydney Bight during the months noted in #1 above. Spring spawning was documented in both places but no cod eggs were found in the fall, although cod in spawning condition were reported in Sydney Bight during early November.

3. Carry out juvenile survey for cod along inshore coast of eastern Nova Scotia in cooperation with a similar offshore survey as part of the Eastern Shelf Programme (ESP) and in support of the Ocean Production Enhancement Network (OPEN). (Lambert)

The offshore component of this project was cancelled due to lack of overtime funding for large vessel cruises. Therefore the inshore component to be carried out under this project was also cancelled. However, a site preferred by juvenile cod was located in Sydney Bight (see #1 above).

4. In cooperation with the inshore fishing fleet in southwest Nova Scotia, develop a program to determine biological and environmental factors that affect catchability and availability of groundfish in NAFO Division 4X and Subarea 5. (a) expand contacts with fishermen through meetings and interviews and develop research topics of mutual interest; (b) analyze existing IOP data from observer deployments in 4X+5; (c) implement program using fishermen to collect environmental data (surface and bottom temperature, wind speed and direction, tide state and direction of flow, bottom depth and type) in association with catch and location data; (d) use IOP observers to collect ancillary environmental data and biological data if observers are deployed in 4X+5; (e) use RV surveys in 4X+5 area on opportunistic basis to supplement environmental data to aid in characterization of water masses; (f) prepare a presentation on the program for FINS. (Hurley, Perry)

Contacts with fishermen expanded through FINS, informal meetings, and port technicians, and included site visits to BIO by several groups of fishermen. In some cases, research questions were explored through on-line data analysis. Preliminary analysis of IOP data conducted. Protective thermometer housings were constructed after consultation with fishermen. Trials with two thermometers indicate

they can be used successfully by draggers, longliners and gillnetters. Twenty thermometers have been placed in the field for the start of the '92 fishing season and the remainder will be placed as soon as it is confirmed that the first group are functioning properly.

5. Evaluate the influences of vessel and gear design and of fishing strategy on the efficiency of inshore fishing vessels in 4X+5. This will assist in future planning of an 'index' fishing program with that fleet. (Hurley)

Concept discussed with fishermen, a marine architect and trawl designers. Data base of vessel and gear characteristics of draggers initiated. Trawl course attended.

6. Develop 'fisherman's almanac' through interviews with fishermen and examination of fishing logs. (Hurley, Frank)

Information for 1990 extracted from port technician weekly progress reports. Fishing records of two dragger fishermen examined and partially extracted. No further progress made due to time constraints.

7. Observe commercial fishing operations. (Hunt, others)

No progress was made on this project.

8. Establish contacts with groundfish fishermen and make arrangements to go out to sea with them to document how commercial operations utilize sounders when groundfishing. (Vacant)

Staffing of this position was delayed. Contact was made but arrangements to participate on a fishing trip are pending.

#### 4. Additional Accomplishments:

Information on cod, redfish and winter flounder distributions from RV surveys provided to fishermen on request. (Hurley)

#### 5. Goals/Expected Outputs for 1992:

1. Undertake bottom trawl program from April to November to monitor cod stock(s) in Sydney Bight particularly with respect to spawning runs. Collect otoliths of spawning fish from Bras d'Or Lake and Smokey Bank for use in shape analysis (see Project #1021). (Lambert)
2. Continue survey of juvenile cod; monitor fixed station for second year with the goal of developing an abundance index, and explore additional areas with trawl and other gear (beach seine, trap) to locate additional sites preferred by young cod. (Lambert)
3. Continue ichthyoplankton survey to measure cod egg production in subdivision 4Vn. (Lambert)
4. In cooperation with the inshore fishing fleet in southwest Nova Scotia, develop a program to determine biological and environmental factors that affect catchability and availability of groundfish in NAFO Division 4X and Subarea 5: (a) expand contacts with fishermen through meetings and interviews and develop research topics of mutual interest; (b) analyze existing IOP data from observer deployments in 4X+5; (c) continue program using fishermen to collect environmental data (surface and bottom temperature, wind speed and direction, tide state and direction of flow, bottom depth and type) in association with catch and location data; (d) use IOP observers to collect ancillary environmental data and biological data if observers are deployed in 4X+5; (e) use RV surveys in 4X+5 area on opportunistic basis to supplement environmental data to aid in characterization of water masses. (Hurley, Page, Perry)
5. Evaluate the influence of vessel and gear design and of fishing strategy on the efficiency of inshore fishing vessels in 4X+5. This will assist in future planning of an 'index' fishing program with that fleet. (Hurley)
6. Observe commercial fishing operations. (Hunt, others)
7. Establish study of winter flounder exploitation rates (Neilson, Gavaris, Kearney (MFU), Neilson replacement). N.B. J. Neilson is taking a leave of absence for 3 years. It is anticipated that his replacement will pursue the winter flounder investigation.

A four-year long study is envisaged. The first year will involve defining principal areas where winter flounder are harvested, identifying fishermen who are willing to participate in a study of catch rates, hiring a local coordinator, establishing liaisons with university investigators (Acadia University, G. Daborn) and, in general, ensuring that study preliminaries are well defined. After the study area has been well-defined from the preliminary investigation, subsequent years will be spent obtaining detailed catch and effort statistics for winter flounder. A special logbook will be compiled by the contractor who will supply DFO with information coded as to vessel, ensuring privacy for volunteering vessels and a reduction in possible biases in the data. Catch rate data will be used to derive exploitation rates and abundance trends.

8. Construct a plastic 'Maturity Disc' that may be kept onboard fishing vessels as a hands-on device to educate fishermen of the vast differences in age and size at sexual maturity among stocks in this region. (Trippel)

#### 6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Interviewed and consulted with 15 fishermen who work mainly in the 4Vn subdivision. Close contact and ongoing consultation has been maintained with about four of these during the course of research work in the area. (Lambert)

iv. Contracts Administered -

Ichthyoplankton sample identification and data analysis with C. Parsons (\$8k). (Lambert)

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Progress on this project has been very good and is following the intent of the AFAP initiative. It has led to a greater awareness of scientists in the industry and an appreciation by scientists of what fishermen can contribute. It is hoped that AFAP funding can continue.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9766

Section: Gulf of Maine

Project Title: Groundfish Ecosystems: Research Information-Survey Data

Project Leader: Gavaris, S.

Other Researchers: Clark, D.; Buerkle, U.; Strong, M.; Hunt, J.; Gale, J.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; abundance; hydroacoustic; index estimates; stock assessment; bottom trawl; surveys

1. Project Description:

Research on developing groundfish abundance index estimates through the implementation of hydroacoustical techniques and a suitable survey design. Research on improving the comparability of trawl survey results by reducing variability introduced by gear performance.

2. Long-Term Objectives:

Provide more precise and accurate groundfish abundance index estimates suitable for stock assessment requirements than those currently available from bottom trawl surveys.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Become familiar with the hydroacoustic equipment and its capabilities. (Vacant, Buerkle)

Participated in a herring hydroacoustic survey and learned the operating practices for the available equipment.

2. Develop protocols to improve standardization of tow parameters which require assessment of the impact of trawling operations such as vessel speed, warp to depth ratios, bottom topography, etc. SCANMAR will be the principle source of these data.

Analysis of SCANMAR data was presented to CAFSAC and will be published as a Technical Report in 1992. New trawl speed sensor was added. SCANMAR course was completed which will allow better interpretation of data.

3. Evaluation of data acquisition software for research surveys with interactive data editing based on a UNIX Oracle version of existing software will be used to assess logistic and environmental limitations for field applications. (Strong, Gale, Hunt)

Branch plans call for the installation of a VAX/VMS system running ORACLE on the R.V. Needler in the coming year; therefore, plans for a UNIX PC based system were shelved.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Observe the use made of sounders by the commercial groundfish fishery. (Clark)
2. Deploy hydroacoustic gear during groundfish bottom trawl surveys, comparing suitability of season. (Clark, Buerkle).
3. Analyze and interpret hydroacoustic data collected during bottom trawl surveys, making recommendations on representativeness of abundance estimates for principal gadoids. (Clark, Buerkle)
4. Become familiar with uses of abundance indices in assessments of groundfish. (Clark)
5. Investigate means of measuring target strength for gadoids with a view to describing the degree of variation. (Clark)
6. Begin development of an at-sea data acquisition and editing system for bottom trawl surveys. (Strong, Gale, Hunt)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Staffing of the acoustics position in St. Andrews took considerably longer than anticipated. However, progress has been steady, particularly in the acquisition of a Dual Beam system. The stage is now set for a productive 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9767

Section: Central Shelf

Project Title: Groundfish Ecosystems: Research Information - Geographic Distribution

Project Leader: O'Boyle, R.

Other Researchers: Mohn, R.; Zwanenburg, K.; Frank, K.; Trippel, E.; Van Eeckhaute, L.; Buzeta, M.; Gavaris, S.; Perry, I.; Waldron, D.; Showell, M.; Hunt, J.

Work Activity: W.A.1.1.1.2

Key Words: groundfish; distribution; ESP; SPANS; spatial distribution; migration; haddock; Georges Bank; cod; Gulf of Maine

1. Project Description:

Analysis of geographically indexed data pertaining to groundfish on the Scotian Shelf to systematically study fish distribution in relation to environmental, biological and fishery factors. Examination of the distribution of fish within management units based on research vessel surveys and fishery distribution.

2. Long-Term Objectives:

To understand the distribution of groundfish and the responses to changes in population dynamics, the environment and the fishery.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Administer a contract to convert existing MFD geographically indexed data bases into SPANS format files. This will include RV surveys, surveillance records and commercial statistics. As well, a set of relevant base maps will be converted or created for coastlines and bathymetry. Additional base maps may be produced if data are available, eg. bottom type. (Fanning)

Due to Fanning's departure, August '91, the contract was not let. The failure to have this contract meant that the following 2 goals could not be achieved. Also, this project was inadequately funded, and the funding which was provided was delayed, which compromised any chance of success.

2. Analyze spatial data from surveys relating oceanographic water masses and distribution of 4Vsw cod. This is contingent upon the successful completion of the data preparation (goal 1 above). This objective is a contribution to the Eastern Shelf Program. (Fanning)

Not undertaken as Goal 1 not done.

3. The interaction between the fleet distribution, based on surveillance or commercial data, and the distribution of resources (RV surveys) will be examined using SPANS. This is contingent upon the successful completion of the data preparation (goal 1 above). (Mohn)

Not undertaken as Goal 1 not done.

4. Contingent upon successful completion of objective 1, characterize the ichthyofauna of Emerald, Western, and Sable Island banks as parts of an overall comparison of the physical and biological characteristics of the submarine banks of the Eastern Scotian Shelf. This objective is a contribution to the Eastern Shelf Program. (Zwanenburg and Frank)

As no contract was let to convert MFD's geographically indexed data bases into SPANS format, no progress was made on this initiative. The analyses will require the use of a geographical information system presently not available to the Division.

5. Study of the distribution of commercial catches of cod, haddock, pollock, silver hake, squid, redfish, flatfish species on the Scotian Shelf. Data from 1977-1990 from the IOP will be superimposed on the distribution patterns from available seasonal surveys. Analytical tools include SPANS or other GIS's. The first part of the analysis will focus on the general distribution of the catch regardless of the size of each species. The second part of the analysis will focus on the distribution of various size categories. Available IOP temperature data and bottom type information will also be used to define the possible habitat of each demersal species. No new data collections are expected. (Waldron, Showell)

Revised priorities during the year resulted in this project being deferred.

6. Monitor the distribution of commercial fisheries for silver hake, cod and haddock on the Scotian Shelf in relation to temperature. Data currently collected from the commercial fishery is dependant on the availability of commercial vessels with temperature recording devices. Study

of onshore migration of silver hake requires constant monitoring from the commercial fleet. In the past Observers have been trained in and supplied with MFD's XBT recorders. This has been expensive and difficult to maintain. The availability of smaller more portable and less costly alternatives such as the SEATEMP probe should provide a cost effective means of collecting some of the required data. The requirement for 1991/92 is to place 5 such probes in the domestic silver hake fishery (areas around Emerald Basin-Western Bank) and the foreign silver hake fishery (along the shelf edge). (Waldron)

Revised priorities during the year resulted in this project being deferred.

7. Describe the spatial distribution of Georges Bank haddock in relation to the potential for movement across the Canada/U.S.A. boundary. Age specific patterns and oceanographic effects will be considered. (Trippel, Van Eeckhaute, Gavaris)

Estimated haddock spatial distribution by age in relation to the transboundary line from U.S.A. research vessel survey data 186-90. Annual age specific migration rates across the boundary line were estimated from 1985-90. Preliminary results were presented to CAFSAC and final revisions are nearing completion. The findings have implications for management of the resource and were presented to GOMAC. (Trippel, Van Eeckhaute, Gavaris)

8. Conduct a study in the Gulf of Maine to assess cod and haddock interaction with adjacent areas. Tag releases, alternate capture methods, estimates of tag induced mortality, age specific migration patterns and investigation of alternative biological tags will be investigated. (Hunt, Van Eeckhaute, Buzeta)

See Goal 6 in Project No. 1013.

#### 4. Additional Accomplishments:

#### 5. Goals/Expected Outputs for 1992:

With resignation of the lead analyst (Fanning) and pressure of other work, the Central Shelf Section is abandoning this project.

1. Investigate use of tagging for determination of haddock migration rates. Initiate literature search and familiarization with topic. Determine what data is available from past tagging experiments and analyze if possible. Investigate possibility of using commercial longliners in tagging experiment and observe commercial longline fishing. (Van Eeckhaute)
2. Plan and conduct a cod tagging experiment in the Gulf of Maine area. (Hunt)

#### 6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

#### 7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

It is evident that with the departure of P. Fanning, and the inadequate funding in 1991, this project was compromised. During the AFAP cutbacks, this was one of the projects targeted for further cuts. It was always planned that this project would draw heavily on A-base resources. During 1992, it will receive limited funding but the intent of the project is being met by A-base initiatives (see projects 1180 and 1250 for example). As well, a large element of Project 9765 is involved with stock structure issues.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9769

Section: Central Shelf

Project Title: Longliner Project - AFAP

Project Leader: Halliday, R.

Other Researchers: Vacant

Work Activity: W.A.1.1.1.2

Key Words: assessment research; groundfish

1. Project Description:

This project, supported by AFAP funds, addresses Recommendation 17(a) of the Report of the Scotia-Fundy Groundfish Task Force which reads: evaluate the biological and economic effects of a longliner allowance fishery including examination of fish selectivity in relation to hook size, type and bait.

2. Long-Term Objectives:

This is a two-year project.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide a report on the current status of the regional longline fishery with regard to biological, economic and technological factors, as a basis for evaluation of potential responses to deregulation of hook and line fishing. (Halliday and Fanning)

The questionnaire survey of Regional longline fishermen, initiated in 1990, was completed in March 1991 and the contractor's report received. Approximately 350 fishermen were interviewed comprising about 30% of active longliners and 7% of inactives. The results of the questionnaire are now being analyzed, with a contractor's report expected early in 1992.

2. Conduct an experiment to compare size selection of hooks and trawl nets when fishing the same populations of fish. The experiment will be designed to yield data on at least two hook and two mesh sizes for both cod and haddock. (Fanning and Halliday)

The experiment was successfully conducted in October using two chartered vessels, the longliner Lady Sharrel and the otter trawler Lady Eileen. The selection properties of three hook sizes (#10, #12 and #14) and two mesh types (130 mm diamond and square netting) were tested against the catches by a small mesh (40 mm) trawl net for cod and haddock. The resultant data are now being computerized and edited for subsequent analysis.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Complete analysis of longline questionnaire survey by making results available in reports suitable for DFO managers and industry. (Halliday)
2. Conduct analysis of longline size selection experiment for cod and haddock, and provide provisional results to DFO managers and industry. (Halliday)
3. Additional hook selection experiments if money and personnel are available. (Fanning replacement)

6. Background:

## Highlights:

Fanning's resignation in August has made completion of this work more difficult, and data analysis and reporting will continue through 1992. However, this AFAP science project was supported for a two year period only, and officially terminates March 1992. Additional hook selections experiments would be rewarding but their conduct depends on extension of funding for this project and success in hiring a replacement for Fanning.

**Selected Involvements:**

## i. Collaborative Research -

C. Cooper and W. Hickey, Fisheries Development, FMB, Halifax, provided significant funding for the longline selection experiment additional to the Science budget, and provided invaluable advice and assistance in conduct of the work. (Halliday)

## ii. University Liaison -

## iii. Communications -

## iv. Contracts Administered -

Analysis of questionnaire data - Gadus Associates (\$20K); Vessel charters for longline/otter trawl selection experiment (\$110K). (Halliday)

## v. Other -

**7. Publications:**

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

Given the limited funding, progress on this project has been exceptional. During 1992, the focus will be on analysis and should wrap the initiative up by 31 March 1993.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9771

Section:

Project Title: Communications - Fishermen

Project Leader: O'Boyle, R.

Other Researchers: MFD Staff

Work Activity:

Key Words: consultation; organization; fishermen; FINS

1. Project Description:

The Haché Task Force on the Scotia-Fundy groundfish fishery commented on the poor level of credibility that the fishing industry has of DFO scientists. Much of the problem lay in poor communication between scientists and fishermen. This program will provide a comprehensive communication strategy to rectify the problem. The groups targeted as part of this strategy include grade 9 high school students, new fishermen, experienced fishermen and the general public.

2. Long-Term Objectives:

To increase awareness and understanding of fisheries science at all levels of the Scotia-Fundy fishing community.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Finalization of grade 9 high school curriculum on fisheries. This will involve consultation with teachers to modify the proposal formulated in 1990/91 (O'Boyle)

In consultation with the Halifax District School Board, a course was defined and outlined. A pilot will be given in June 1992 with implementation in the classroom in the following fall.

2. Ongoing implementation of Masters Ticket Program (MTP) initiative with consideration of expansion to New Brunswick (O'Boyle)

Six lectures were given in the MTP series. Plans were made for the 1992 series. Also the presentations were compiled into a standard format.

3. Ongoing FINS exercise (MFD Staff)

The Nova Scotia Fisheries Exhibition was attended by a Divisional team. In addition, a number of smaller meetings were held with the various associations.

4. Ongoing production of newspaper articles, support of dial-a-scientist and industry report (MFD Staff)

Production of the industry report was limited to the section on cod, due to funding cuts. In St. Andrews, support was provided for the production of a chapter in Scott Parson's book on fisheries management.

5. Participate in FINS and other consultations with fishermen's organizations. (Gavaris, Neilson, Trippel, Hunt)

Staff met with fishermen's organizations in Yarmouth, Cape Sable and Grand Manan to discuss the status of groundfish resources and plans for research activities. Meetings well attended with good interchange of biological and fishery information.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

This project will be incorporated into the existing A-base initiatives.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project received limited funding and was the target of further cuts in 1991. The initiative is seen as a modest priority and will be pursued as much as possible using A-base funding.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9813

Section: Marine Mammals

Project Title: Seal/Sealworm Ecology - Diet/Parasite Studies

Project Leader: Bowen, D.

Other Researchers: McClelland, G.; Stobo, W.

Work Activity:

Key Words: seals; Atlantic Fisheries Adjustment Program; diets; sealworm abundance

1. Project Description:

This project provides additional funding to meet the objectives of the Seal/Sealworm Ecology Program (SSEP) associated with studies on the diets of grey and harbour seals and the abundance of sealworm in seals and fish species which are either commercially important and/or are important foods of seals.

2. Long-Term Objectives:

To provide data on seal diets and sealworm abundance in seals and fish for use in developing models of the population dynamics of sealworm. The results from such modelling studies will be useful in providing advice to managers on seal/fisheries interactions.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Measure metabolic rate of adult female harbour seals on Sable Island, using doubly-labelled water, to determine total energy expenditures over the lactation period. (Bowen)

Doubly-labelled water was administered to 5 free-ranging adult harbour seal females to determine metabolic rate during early and late lactation on Sable Island in May 1991. Analysis of both water isotopes will be completed by the end of the fiscal year. Calculations to determine metabolic rates will be completed in 1992.

2. Continue a preliminary study on the proximate composition and energy density of seal prey and the use of fatty acid signatures of major seal prey to determine major components of the diet of grey and harbour seals using Sable Island. Work to be done in Dr. R. Ackman's laboratory at TUNS, Halifax. The work has two main objectives: a) to enable more reliable estimates of food intake of seals by determining seasonal variation in caloric content of seal food, and b) to provide a means of obtaining information on the diets of seals in offshore locations around Sable Island. (Bowen)

This work did not proceed as planned. AFAP funds were frozen before a contract could be arranged to conduct the work.

3. Complete identification and enumeration of nematodes from grey seal stomachs collected during the seasonal survey on Sable Island. (McClelland, Stobo, and Martell)
4. Identification of food and parasitic nematodes from stomachs of recently weaned grey seals on Sable Island to determine source of initial sealworm infection. (McClelland, Beck, Martell)

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Collect additional seal stomachs, with emphasis on grey seals, from selected hunters at previously sampled locations in Scotia Fundy Region. (Bowen)
2. Determine energy requirements of free-ranging adult and juvenile male harbour seals using doubly-labelled water to provide data for models of population energy requirements of seals on the Scotian Shelf. (Bowen)

6. Background:

Highlights:

## Selected Involvements:

## i. Collaborative Research -

## ii. University Liaison -

Thesis supervisor of four graduate students at Dalhousie University: K. Glazebrook (formerly Barker) - isotope dilution estimates of food intake and ultrasound estimates of changes in body composition of captive harbour seals; M. Muelbert - lactation strategies in South American fur seals; P. Ross - immune function in harbour seals; B. Walker - reproductive ecology of male harbour seals. (Bowen)

Theses supervised - K. Glazebrook. 1991. The use of ultrasound and isotope dilution to estimate body composition and food intake in pregnant and non-pregnant captive harbour seals (Phoca vitulina concolor). M.Sc. Thesis, Dalhousie University, Halifax. (Bowen)

## iii. Communications -

Interviewed by Canadian Geographic for a Geo Watch article. (Bowen)

## iv. Contracts Administered -

Analysis of grey and harbour seal diets - J. Lawson (\$5.2 and \$6 K); Analysis of 0-18 samples - Stable Isotope Lab, Boston University (\$3.3 K). (Bowen)

## v. Other -

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Progress on this project was good and complementary to the other elements of the program.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Marine Fish Division

Project No.: 9814

Section: Marine Mammals

Project Title: Seal Population Monitoring

Project Leader: Stobo, W.

Other Researchers:

Work Activity: W.A.1.1.1.4

Key Words:

1. Project Description:

Monitor population trends of grey seals on the Scotian Shelf for the assessment of population status of grey seals and the provision of biological advice to managers.

2. Long-Term Objectives:

Monitor grey seal pup production trends on Sable Island and elsewhere on the Scotian Shelf (if new populations develop) to provide a basis for the sound management of this species. To develop and standardize a protocol for the regular estimation of pup production via aerial surveys or other techniques.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Develop the protocols and quality checks and issue a contract to analyze imagery of the 1989 and 1990 aerial surveys to estimate Sable Island grey seal pup production. (Stobo)

Contract to read aerial photographs completed, including calibration checks to ensure contractor was obtaining consistent readings.

2. Participate in annual meeting of SSEP to present progress survey analysis. (Stobo)

No SSEP meeting held. Attended meeting of CAFSAC Marine Mammal Subcommittee held in Feb/91 and presented estimates of Gulf pup production from tag resighting on Sable; attended second meeting of CAFSAC MM Subcommittee held in Oct/91.

4. Additional Accomplishments:

1. Paper on duration of pelage stages of grey seal pups submitted to Marine Mammal Science under revision. (Myers, Bowen, and Stobo)
2. Conducted helicopter survey throughout Bay of Fundy to count harbor and grey seals and obtain a ratio of species mix. (Stobo)

5. Goals/Expected Outputs for 1992:

1. Conduct analysis of 1989 and 1990 aerial surveys comparing estimates with known pup production from complete cohort tagging. (Stobo)
2. Conduct aerial photographic survey of 1993 grey seal pup production on Sable Island. (Stobo)
3. Participate in annual meeting of SSEP to present progress on survey analysis. (Stobo)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -

Developed model of grey seal pup pelage stage progression as an element of estimating production from aerial surveys with Newfoundland Region scientist. (Myers, Bowen, Stobo)

- ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

Contract to read 1989 and 1990 aerial surveys and calibrate reading (\$7.5k). (Stobo)

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project replaces the grey seal tagging component in the 1980 project 'Population Ecology and Assessment of Seals'. It represents an adaptation of the grey seal population monitoring requirement to deal with the practical difficulties of tagging over 10,000 seals annually. It was initiated under SSEP and it is anticipated that such a survey will be required at least once every 2 to 3 years.



PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 200

Section: Informatics and Administrative Support

Project Title: Informatics

Project Leader: Swetnam, D.

Other Researchers: Hunter, C.

Work Activity: W.A.1.1.1.3

Key Words: support; data processing; computer

1. Project Description:

This project provides an essential support function to the research scientists and other BF&A Division staff. The provision of computing resources, training, development of specialized computer software, EDP planning, selection and procurement of EDP equipment and software, and consultation on data processing matters for the Division have been concentrated into this project. The project personnel also provide critical contacts with the fast moving computer field, making it possible for the scientific staff to accrue the benefits of recent developments and new techniques.

2. Long-Term Objectives:

To provide electronic data processing and analyses to scientific research and management projects of the BF&A Division by:

1. Computer programming, systems analysis, and consultative services to Division personnel.
2. Making available computing facilities and resources, both hardware and software, to the Division.
3. Designing and implementing data entry, storage and retrieval systems.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Supply day-to-day EDP service, support, development and training. (Hunter)

Goal met. Bulk of this service supplied by Hunter to members of the Division. Major accomplishments were; further design and implementation of the lobster fishery ORACLE data base. (Tremblay, Pezzack, D. Duggan, R. Duggan). Swetnam provided regular system and application maintenance and upgrades; Communication network extensions, maintenance upgrades and documentation. Installation of LAN E-Mail system some day-to-day assistance and program development.

2. Integration of the Halifax Lab LAN into Regional WAN including SQL\*NET connectivity. (Swetnam)

Goal met. Lab was completely rewired using Ethernet 10 base T standards connecting to a 36 port concentrator. Ethernet cards were installed in Macs and PCs and configured to run both TCP/IP and Ethertalk protocols. Localtalk and Ethernet networks were integrated using TOPS and Liaison software. SQL\*NET connectivity was accomplished to BIO (Cyber) and is expected to be installed at St. Andrews before December 31, 91.

3. Ensure laboratory personnel have converted files to NOS/VE format by March 31/91. Hire a term CS to assist with conversion. (Swetnam)

Goal met. All NOS/VE systems were converted or in a form that is accessible to the new operating system by the target date.

4. Instruct and train staff in the use of E-Mail and wide area networking. (DFONET, INTERNET, FTP, TELNET). (Swetnam)

Goal met. Individual staff were instructed in the use of Telnet and FTP. Courses were given for DFONET, E-Mail and Internet access. Telnet for the PC is planned for late December.

5. Do all possible to have in place the most suitable MA candidate by March 31/91. (Swetnam)

Goal met. A statistical consultant was hired in the ES category August 1, 1991. This was the earliest date possible due to delays in classification.

6. Introduce and train staff in the use of the ORACLE data base system. (Hunter)

Goal met. J. Tremblay, D. Pezzack, M. Eagles, D. Duggan, R. Duggan trained. M. Lundy to be trained before end of year.

7. Design creation and implementation of ORACLE data bases such as scallop and IOP invertebrate edits. (Hunter)

Goal partially met. Scallop for Bay of Fundy mostly complete to be finished and documented by end of December. IOP edits deferred until MFD implements IOP system.

8. Training of staff in use of NOS/VE & FSE. (Hunter)

Goal met. Documentation for FSE and NOS/VE produced. (C. Hunter)

9. Advise the Branch Executive and SIWC on EDP matters, if continuing as Chair of BSBCAC and Communications Subcommittee. (Swetnam)

Goal met. Continued in BSBCAC chairman capacity until December 31, 1991. Represented BSB on DFO/DEMR working group, SIWC and Communications subcommittee. Prepared Branch input into Cooperative Computing document and EDP workplans.

#### 4. Additional Accomplishments:

1. The section assisted people from other Divisions; Freshwater and Anadromous, Habitat Ecology, and Marine Fish Divisions. Support was also given various graduate students, visiting scientists, summer students and other Branches of DFO.
2. Scallop edit systems were converted from COBOL to FORTRAN thus ending our involvement in COBOL.
3. All ORACLE databases were converted to version 6.0.
4. Documentation on the Lobster Logs and Bay of Fundy Scallop Log systems was prepared.
5. Manuscript describing the Oracle Lobster database was prepared, and is currently under review.

#### 5. Goals/Expected Outputs for 1992:

1. To provide leadership to the Section with particular emphasis in 1992 on the new mathematics position. (Swetnam)
2. Supply day-to-day EDP service, support, development and training. (Hunter, Swetnam)
3. Integration of the Halifax Lab analyses systems via Regional WAN and SQL\*NET to off site ORACLE databases. (Swetnam, Hunter, Black)
4. Evaluate, and implement if feasible extending, E-Mail services to the desktop in a real time fashion, train staff. (Swetnam)
5. Continued training of staff in the use of newly implemented systems such as ORACLE. (Hunter)
6. Design creation and implementation of ORACLE data bases such as IOP invertebrate edits. (Hunter, Swetnam,)
7. Conversion of Cyber systems to Cyber replacement(s). (Hunter, Swetnam)
8. Advise the Branch Executive and SIWC on EDP matters. (Swetnam)

#### 6. Background:

##### Highlights:

The current year has been consumed by three major initiatives; implementation of the Halifax Lab IEEE802.3 Local Area Network, NOS/VE conversion and ORACLE data base implementation. The upcoming year will see another conversion effort begin as the Cyber lease expires, a continuing of ORACLE work and closer ties of the analysis systems to off site Oracle databases. Also a considerable amount of time will be spent training staff to use new software systems.

##### Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

D. Swetnam administered the contract to have MT&T completely rewire the Laboratory's LAN.

- v. Other -

#### 7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

The project is going well. The Section Head ended a 2.5 year stint as Chairperson of the BSBCAC where he served in an exemplary fashion. Another major task handled well, was the hiring of a mathematician. Project staff are frequently lauded for the service performed. A most valuable project for which full support should continue.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 201

Section: Population Biology

Project Title: Larval Ecology and Lobster Assessment (LFA 33)

Project Leader: Tremblay, J.

Other Researchers: Duggan, R. ; Pezzack, D. ; Sinclair, M. ; Hunter, C.

Work Activity: W.A.1.1.1.3

Key Words: fisheries ecology ; assessments ; population dynamics ; invertebrate larvae

1. Project Description:

The project investigates the distribution and ecology of larval sea scallops in commercially-important areas, particularly Georges Bank. The broad scale horizontal distribution, and the vertical distribution of larvae in relation to physical and biological factors is emphasized. Techniques to assess larval condition and age in nature are studied, using laboratory reared larvae.

2. Long-Term Objectives:

To better understand the role of the larval period in the determination of recruitment and population structure in commercially-important invertebrates, and to provide biological advice in the management of the lobster fishery.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Submit for publication papers entitled: (1) The broadscale distribution and abundance of sea scallop larvae in the Georges Bank region; (2) The distribution of sea scallop larvae across the frontal zone of the Northern Flank of Georges Bank.

Goal met. A single paper combining (1) and (2) has been submitted to the Canadian Journal of Fisheries and Aquatic Sciences.

2. Communicate biological advice to fishermen at LFA 33 meetings and elsewhere as required. Provide reports on ongoing monitoring of catch-rates and size composition, and recent biological research.

Goal met. Biological information presented at two LFA 33 meetings.

3. Analyze recent catch-rates of lobster from logbooks in LFA 33. Examine variability due to fisherman, month and year.

Goal met. Working paper on above subject presented to Statistics, Sampling, and Surveys Subcommittee of CAFSAC.

4. Initiate study of the condition of lobster larvae. Measure the lipid class composition (by contract) in larvae obtained in the inshore in 1990. Compare with lipid levels in: (1) lab reared larvae (published); and (2) Georges Bank larvae. Consider the type of laboratory and field studies necessary to better understand the factors affecting larval survival. Potential collaboration with J. Castell.

Goal not met. No progress due to other priorities.

5. Continue development of lobster fishery data base. Improve form for input of logbook data (LOGDATA), develop form for input of length frequency data. Develop more end-user queries and revise documentation (with C. Hunter and D. Pezzack).

Goal met. Database improved substantially. A manuscript report describing its use (Hunter, C., and M. J. Tremblay. 1992. A database for catch and length composition data related to the Scotia-Fundy lobster fishery) is currently being reviewed internally.

4. Additional Accomplishments:

1. Gave overview talk to Offshore Scallop Advisory Committee (OSAC) on Biological Sciences Branch studies of planktonic sea scallop larvae (April)
2. Presented papers on distribution and ecology of sea scallop larvae at (i) American Society of Limnology and Oceanography Meeting, and (ii) National Shellfisheries Association Meeting.

5. Goals/Expected Outputs for 1992:

See Section 8. Review and Evaluation

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

I. Perry (MFD), G. Harding (HED), J. Loder (PCS), M. Sinclair (BSB): Georges Bank frontal study and GLOBEC.

ii. University Liaison -

External examiner of Dalhousie University M.Sc. thesis (Mr. Wei Ding).

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Tremblay, M. J. 1991. Sea scallop larvae (Placopecten magellanicus) in the Georges Bank region: distribution, abundance and condition. Ph.D. thesis, Dalhousie University, Halifax, N.S. 201 p.

iv. Popular and Miscellaneous -

Tremblay, M. J. 1991. Inshore-Offshore lobster problem still a problem. Weekly Scientific Briefing, Vol 10, No. 4, Jan 25, 1991.

Tremblay, M. J. 1991. Summary sheet 1991- Lobster, LFA 33, South Shore, N.S. Presented to IMP Subcommittee of CAPSAC, Feb. 1991.

Tremblay, M. J. 1991. Does the behaviour of sea scallop larvae influence their dispersal? (Abstract). J. Shellfish Res. 10: 273.

Tremblay, M. J., and M. Sinclair. 1991. Inshore-offshore differences in the distribution of sea scallop larvae: implications for recruitment (Abstract). ICES mar. Sci. Symp. 132: 39.

Tremblay, M. J. 1991. Factors affecting distribution (Workshop Report). ICES Mar. Sci. Symp. 132: 40.

8. Review and Evaluation:

Components of this project will be transferred to project no. 206 (scallop larval ecology) and 211 (lobster assessment for LFA 33) respectively.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 202

Section: Population Biology

Project Title: Lobster Resource Science

Project Leader: Hudon, C.

Other Researchers: Pezzack, D. ; Duggan, D.

Work Activity: W.A.1.1.1.2

Key Words: lobster biology ; early life history ; juvenile habitat ; recruitment

1. Project Description:

Assessment and review of information currently available on lobster populations found inshore and offshore South West Nova Scotia. Elaboration of hypotheses on the possible relationships between inshore and offshore lobster "populations". Research into the ecology, growth, life history and population dynamics of lobster.

2. Long-Term Objectives:

Obtain and integrate information on the biology and ecology of lobster. Enhance understanding of factors determining lobster recruitment in the inshore and offshore areas of the northern Gulf of Maine.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Review of information on inshore-offshore lobster; following lobster review a long-term research plan will be developed. (Hudon)

Goal met. The information on inshore-offshore lobster was reviewed through participation to a special DFO Workshop on that subject and involvement with writing of the report (see publications). A long-term research plan for lobster resource science was developed. (Hudon)

2. Preliminary field exploration for juvenile lobster habitat and underwater observations of berried females. (Hudon)

Goal met. Preliminary field exploration for juvenile lobster habitat and underwater observations were carried out. A preliminary experiment to develop a postlarval and juvenile lobster collector was carried out in collaboration with the Quebec Region. (Hudon)

3. Participation in the survey on intensity and distribution of lobster fishing effort in the middle ground area of LFA 34 (South West Nova). (Pezzack)

This documented in Project No. 214.

4. Publication of previously collected data on northern Quebec fisheries research. (Hudon)

Previously collected data on northern Quebec fisheries research was analyzed and published in the primary literature (see publications). (Hudon)

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Prepare and have reviewed a long-term research plan on lobster populations, by characterizing the physical conditions of inshore lobster fishing areas of Southwest Nova Scotia, with emphasis on seasonal and year-to-year variability of thermal regime.
2. Continue studies on juvenile lobster ecology and habitat preference by improving the prototype of lobster collector previously designed and testing its performance in the laboratory and in the field.

6. Background:

Highlights:

## Selected Involvements:

## i. Collaborative Research -

1. M. Jean-Paul Dallaire, DFO, IML, Mont-Joli. Development of a collector for postlarval and juvenile lobster.

## ii. University Liaison -

Adjunct professor at the Dept. of Renewable Resources, McGill University.

Supervision and direction of 2 students: Raul Ugarte (Ph.D. candidate, Dalhousie University, Halifax) and Andrew Bauder (BSc Honours, Dalhousie University, Halifax). Mr. Ugarte's thesis deals with the behaviour of berried female lobsters as a factor regulating the timing of egg hatching in the natural environment. Mr Bauder's thesis deals with the yearly pattern of bottom water temperature in relation with the timing of stage I larval occurrence along the southern shore of Nova Scotia (LFA 33).

## iii. Communications -

## Seminar and Presentations:

Participation in APICS (First Annual Atlantic Student Citizens' Science Conference), as a scientific interviewee for the Student Media Challenge. November 1991.

Participation in the planning and collection of the Internal DFO Communication Survey. June 1991.

Speaker for primary grade school groups visiting BIO during the summer.

## iv. Contracts Administered -

Mr. Raul Ugarte, Contract for the analysis of benthos samples from lobster collectors.

## v. Other -

7. Publications:

## i. Primary -

Hudon, C., P. Legendre, J.M. Lavoie, J.-M. Dubois and G. Vigeant. 1991. Effets du climat et de l'hydrographie sur le recrutement larvaire du homard américain (Homarus americanus) dans le nord du Golfe du Saint-Laurent. Can. Spec. Publ. Fish. Aquat. Sci. 113: 161-177.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

Henderson, M., Hudon, C. and D. Meerburg. 1991. Review of Atlantic salmon assessment programs in the Freshwater and Anadromous Division Biological Science Branch in Scotia-Fundy Region. 30 p.

8. Review and Evaluation:

The first year of this project was positive; a new direction was taken in lobster resource science and it was a delight to have such an enthusiastic field ecologist on staff. Research on the juvenile ecology of lobsters is of utmost importance to the understanding of the species biology and ultimately, fisheries management. Preliminary results on a postlarval/juvenile lobster collector are encouraging. Christiane has spent considerable time writing manuscripts from data collected elsewhere. This task should now take second place to her Regional project.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 203

Section: Population Biology

Project Title: Scallop Assessment and Research

Project Leader: Robert, G.

Other Researchers: Black, G. ; Butler, M. ; Thouzeau, G.

Work Activity: W.A.1.1.1.3

Key Words: assessments; assessment research; scallops; resource surveys

1. Project Description:

Annual stock assessments of the scallop fisheries in the Scotia-Fundy Region (NAFO Divisions 4VWX and 5YZ) are conducted for management purposes (CAFSAC, advisory committees, and DFO fishery managers). A research program in support of these assessments is carried out and advice is interpreted for clients.

2. Long-Term Objectives:

Provide sound biological advice on the various scallop fisheries in the Scotia-Fundy Region and to conduct that research deemed most likely to improve this advice; effectively communicate this advice to industry and resource managers.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Perform a complete assessment of Georges Bank and Scotian Shelf scallop stocks (Scotian Shelf, and Georges Bank), and prepare research document. (Robert)

Scallop stocks were assessed and evaluations, including both TAC advice and experimentation with ADAPT, were presented at the CAFSAC Invertebrates meeting.

2. Conduct stock surveys, fishery analysis, and port sampling, for stock assessments. (Robert)

Research vessel surveys were conducted on the eastern and western Scotian Shelf and on Georges Bank. Insufficient ship resources reduced surveys. Fishing data such as scallop beds fished, effort, and CPUE were analyzed. Port sampling activities included the collection of gonad materials in addition to catch monitoring. Port sampling was expanded to cover all offshore enterprises involved in the fishery on an experimental basis.

3. Present biological advice to Regional Scallop Advisory Committees, prepare biologically based briefing documents when required, and participate in other DFO-sponsored activities pertaining to the resource management of scallops. (Robert)

Presentations made on the status of the resource, as required, to the Offshore Scallop Advisory Committee. Briefing made to the Scallop Working Group on variable meat count. Presentations made to the Scallop sector of the Seafood Producers Association of Nova Scotia on the variable meat count, survey logistics, and port sampling. A Scallop Science Day provided the industry with seminars on current research activities and the derivation of a TAC using catch-at-age data coming from port samples calibrated against research survey index and catch-rate information.

4. Complete the project on the ecology of juvenile sea scallops on Georges Bank. (Thouzeau)

Goal not met. Results have been published on the faunistic assemblages of Georges Bank scallop beds and on the distribution and variability of growth in juvenile scallops (see below). Another manuscript looks more closely at the distribution of age 1 scallops. G. Thouzeau attended the annual meeting of the Marine Benthic Ecology Society in March to give a summary of these findings.

5. Continue the analysis of scallop pro-rating factor and meat count as a management tool. (Robert)

Analysis was completed on the statistical validity of the meat count and findings presented at the annual meeting of American Statistical Association in August.

6. Carry out a study on the reproductive ecology of the offshore deep-sea scallop. (Robert)

With graduate student, C. DiBacco, sampling carried out to get monthly profiles; histological analysis kept pace with sampling. Techniques are being implemented to calculate the volume of gonadal components by image analysis. Presentations were made at the Marine Benthic Ecology Society meeting in March, 1991, the National Shellfisheries Association meeting and the International Pectinid Workshop.

7. Software development and conversion in support of analytical programming for scallop stock assessments. (Robert)

The scallop analysis software was streamlined and the conversion from NOS to NOSVE completed.

8. Assess the Scotia-Fundy commercial shrimp fishery and report to the Advisory Committee. (Butler)

The shrimp fishery was evaluated through the analysis of log data and presented at the CAFSAC Invertebrates meeting. A TAC was set for the next three years. Biological advice was provided at the Advisory Committee annual meeting. Local fishermen's queries were replied to. A biological overview of Scotia-Fundy shrimps was given at a Shrimp Seminar for fishermen in February. The separator trawl is improving the prospects for this fishery; exploratory licenses landed 500 t in 1991.

#### 4. Additional Accomplishments:

1. Presentation of two communications at the 8th International Pectinid Workshop in May on variability and growth of juvenile scallops and on reproductive ecology and its implications to stock recruitment.
2. Participation in a workshop with representatives of the French scallop fishing industry to discuss comparative management strategies between France and Canada.
3. Participation at the ICES Pectinid Working Group in June to discuss recruitment dynamics of pectinids and management strategies.
4. Updated (new biological knowledge, recent fisheries statistics, and editing) to the scallop atlas manuscript.
5. Collaboration with Conservation and Protection with respect to illegal fishing activities on Browns Bank by identifying point of origin of seized scallop samples.
6. Member of the PERD Georges Bank Steering Committee.

#### 5. Goals/Expected Outputs for 1992:

1. Perform a complete assessment of Georges Bank and Scotian Shelf scallop stocks and prepare research documents. (Robert)
2. Conduct stock surveys, fishery analysis, and port sampling for stock assessments. (Robert)
3. Present biological advice to Regional Scallop Advisory Committee, prepare biologically based briefing documents when required, and participate in other DFO-sponsored activities pertaining to the resource management of scallops. (Robert)
4. Complete the project on the ecology of juvenile sea scallops on Georges Bank, with a paper on filter-feeding species competitive interactions. (Robert)
5. Complete the analysis of scallop pro-rating factor. (Robert)
6. Continue the study, with MSc student C. DiBacco, on the reproductive ecology of the offshore deep-sea scallop. (Robert)
7. Software development and conversion in support of analytical programming for scallop stock assessments. (Robert)
8. Assess the Scotia-Fundy commercial shrimp fishery and report to the Advisory Committee. (Butler)

#### 6. Background:

##### Highlights:

In recognition of her great interest in scallop fisheries management issues, the French scallop fishing industry dedicated a vast scallop seeding project in Cherbourg Harbour "Operation Ginette".

##### Selected Involvements:

##### i. Collaborative Research -

S.J. Smith, MFD, on the statistical validity of the meat count procedure.

##### ii. University Liaison -

J. Grant, Dept of Oceanography, Dalhousie University. Masters student, C. DiBacco on the reproductive ecology of the deep-sea scallop.

##### iii. Communications -

Interviews on the English radio and French TV networks.  
Enquiries from local newspapers and trade journals.  
Submitted information for article on scallop spawning, Sou'wester Oct.1st.  
Preparation of Weekly Scientific Briefings.

##### iv. Contracts Administered -

Commercial port sampling activities for the offshore fleet. Collection of gonad material for histological identification of maturity stages. Industry funding provided expansion of port sampling to cover the entire fleet as an experimental project.

v. Other -

## 7. Publications:

### i. Primary -

Thouzeau, G., G. Robert, and R. Ugarte. 1991. Faunal assemblages of benthic megainvertebrates inhabiting sea scallop grounds from eastern Georges Bank, in relation to environmental factors. *Mar. Ecol. Prog. Ser.* 74: 61-82.

Thouzeau, G., G. Robert, and S.J. Smith. 1991. Spatial variability in distribution and growth of juvenile and adult sea scallops *Placopecten magellanicus* (Gmelin) on eastern Georges Bank (Northwest Atlantic). *Mar. Ecol. Prog. Ser.* 74: 205-218.

Thouzeau, G. and D. Vine. 1991. Offshore sampling of the megabenthos techniques applied on Georges Bank. *Comptes-rendus Acad. Sci. serie III vol. 312 (12):607.*

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

Butler, M.A.E. and G. Robert. 1991. Update of the Scotian Shelf shrimp fishery - 1990. CAFSAC Res. Doc. 91/23, 15p.

Robert, G., G.A.P. Black, and M.A.E. Butler. 1991. Georges Bank scallop stock assessment - 1990. CAFSAC Res. Doc. 91/29, 34p.

Robert, G. and M.A.E. Butler. 1991. Scallop fishing grounds on the Scotian Shelf - 1990. CAFSAC Res. Doc. 91/25: 31p.

Robert, G. 1991. Report of the Working Group on pectinid stocks. Brest, France. ICES C.M. 1991/K: 43, 21p.

Smith, S.J. and G. Robert. 1991. Scallops, sampling, and the law. Proc. American Statistical Association annual meeting, 1991. Atlanta, Georgia.

### iv. Popular and Miscellaneous -

Robert, G. 1991. (Abstract) Reproductive ecology of *Placopecten* on Georges Bank and its implications to stock recruitment. 8th International Pectinid Workshop, Cherbourg, France.

Robert, G. 1991. Un aperçu de la gestion de la pêche aux pétoncles au Canada. Presentation at a workshop with the French scallop fishing industry. Cherbourg, France, May, 1991.

Thouzeau, G. and G. Robert. 1991. (Abstract) Spatial variability of the distribution and growth of juvenile sea scallops in relation to environmental conditions on eastern Georges Bank. 8th International Pectinid Workshop, Cherbourg, France.

## 8. Review and Evaluation:

This project consists of three distinct parts; stock assessment; communication and provision of advice and resource science. Industry of late lost a little confidence in the biological advice leading to the annual TAC. Steps have been taken to improve the problem areas (gaps in port sampling and inaccurate vessel logs). As well, an enhanced biological science program will provide an improved understanding of recruitment. Work has been carried out to improve ADAPT to better suit the scallop cohort analysis, but further analysis is required to discern the usefulness of this procedure. As usual, communication with all groups of clients was superb and the resource science studies have gone extremely well. A couple of tasks were unfulfilled due to a health problem (chronic sciatic nerve) of the Project leader.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 204

Section: Population Biology

Project Title: Offshore Clams Assessment and Research

Project Leader: Roddick, D.

Other Researchers: Kenchington, E.

Work Activity: W.A.1.1.1.3

Key Words: clams; assessments; assessment research; scallops; resource surveys

1. Project Description:

Conduct annual Scotian Shelf offshore clam assessments (Mactromeris polynyma and Arctica islandica) as required for management of the fishery. Research into the biology of the species and assessment methodology is conducted to improve the accuracy and precision of biological advice. Participate in industry/management meetings as required to explain or elaborate assessments and advice on alternate management strategies.

2. Long-Term Objectives:

To provide biological advice on Scotian Shelf clam stocks (Mactromeris polynyma and Arctica islandica), and improve the quality of advice as new information and/or methodologies become available through research and additional commercial data. To further develop the scientific information base for future management of currently underexploited and unexploited species.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide stock assessment for Scotian Shelf offshore clams. (Roddick)

Completed. Stock assessment presented to 1991 CAFSAC Invertebrates Committee Meeting. Landings are far below the TAC.

2. Present biological advice to Offshore Clam Advisory Committee and the Inshore Quahaug Working Group. Prepare biologically-based briefing documents when required, and participate in other DFO-sponsored activities pertaining to the resource management of clams. (Roddick)

Completed. Meetings of the Offshore Clam Advisory Committee and the Inshore Quahaug Working group were attended and presentations made, as required, on the status of the resource and the biological advice for management.

3. In cooperation with Dr. F. Tan of Physical and Chemical Sciences Branch use the oxygen isotope technique to verify the use of chondrophore rings for ageing offshore clams, if problems with their analytical procedures can be solved. (Roddick)

Incomplete. Physical and Chemical Sciences believe they have solved their problems with the analysis and have upgraded their equipment. They are presently working on a backlog of samples, but do hope to begin the analysis this winter.

4. Continue with analysis of samples from Banquereau Bank and inshore banks to determine the reproductive cycle and age-at-maturity of Mactromeris polynyma. (Roddick)

Sampling of Banquereau Bank had to be dropped when the commercial fleet, which supplied samples, changed it's fishing patterns. Samples are being routinely collected from the inshore area and a full year's worth have been processed. Sampling will continue until the late fall of 1992.

5. Continue the collection and ageing of Mactromeris polynyma to increase the accuracy of growth data. (Roddick)

Collection and processing of samples is continuing, emphasis is being placed on small and large specimens to increase accuracy on the tails of the growth curve.

4. Additional Accomplishments:

Conducted an exploratory survey for small surf clams on the Eastern Scotian Shelf with funding from Development Branch.

5. Goals/Expected Outputs for 1992:

1. Provide stock assessment for Scotian Shelf offshore clams. (Roddick)

2. Present biological advice to Offshore Clam Advisory Committee and the Inshore Quahaug Working Group. Prepare biologically-based briefing documents when required, and participate in other DFO-sponsored activities pertaining to the resource management of clams. (Roddick)
3. Write up report on exploratory surf clam survey. (Roddick)
4. In cooperation with Dr. F. Tan of Physical and Chemical Sciences Branch use the oxygen isotope technique to verify the use of chondrophore rings for ageing offshore clams if samples can be processed. (Roddick)
5. Complete sampling program for inshore stock to determine the reproductive cycle. (Roddick)
6. Finish analyzing samples and start writing up study on age-at-maturity of Mactromeris polynyma. (Roddick)
7. Continue the collection and ageing of Mactromeris polynyma to increase the accuracy of growth data. (Roddick)
8. Investigate cost of joint Scotia-Fundy:Newfoundland charter of the Delaware II from Woods Hole for a 4-6 week clam survey. (Roddick)

## 6. Background:

### Highlights:

#### Selected Involvements:

##### i. Collaborative Research -

- F. Tan, Physical and Chemical Sciences Branch - Oxygen isotope analysis for ageing of bivalves;
- S. Naidu, Biological Sciences, Nfld Region - Research on the biology and assessment methodology of Mactromeris polynyma;
- T. Landry, Biological Sciences, Gulf Region - Survey and assessment methodology for offshore clams.

##### ii. University Liaison -

##### iii. Communications -

##### iv. Contracts Administered -

Three month contract for technical services with Gayle Hartlen for processing samples from Surf clam exploratory survey.

##### v. Other -

## 7. Publications:

### i. Primary -

Cai, D., F.C. Tan and D.L. Roddick. 1990. Oxygen isotope studies on the growth rate of sea scallop, Placopecten magellanicus from Brown's Bank, Canada. *Oceanologia et Limnologia Sinica* 21 (6): 550-558.

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

### iv. Popular and Miscellaneous -

Roddick, D.L. 1991. CAFSAC Invertebrates Committee Summary Sheet - Banquereau Bank Arctic surfclam, Mactromeris polynyma, 1991.

## 8. Review and Evaluation:

This project is progressing nicely. An offshore exploratory survey took place last spring, which found areas of small-size. Basic biological information on ageing and the reproductive cycle is being gathered, which ultimately will enhance the understanding of offshore clam recruitment.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 205

Section: Population Biology

Project Title: Scallop Research

Project Leader: Kenchington, E. (nee Rice)

Other Researchers: Lundy, M. ; Roddick, D.

Work Activity: W.A.1.1.1.3

Key Words: scallop assessment ; morphometric analyses; scallop genetics ; ecology

1. Project Description:

Conduct annual assessment of the Bay of Fundy (Digby) scallop fishery. Research the population dynamics and ecology of Placopecten magellanicus.

2. Long-Term Objectives:

To improve the quality of advice on the Bay of Fundy scallop stock. To enhance the understanding of the biology of commercial scallop species.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide a stock assessment of the Bay of Fundy scallop resource. (Kenchington)

Completed. A stock assessment of the Bay of Fundy (Digby) scallops was presented at the 1991 CAFSAC Invertebrates Committee Meeting. A CAFSAC research document (91/26) was produced on the status of the resource. (Kenchington)

2. Present biological advice to Inshore Scallop Advisory Committee. Prepare biologically based briefing documents when required and participate in other DFO sponsored activities pertaining to the resource management of scallops. (Kenchington)

Completed. All meetings (3) of the Inshore Scallop Advisory Committee (ISAC) were attended and advice was presented at each of them. A biological presentation (both oral and written) was given to a meeting of the Offshore Scallop Advisory Committee (OSAC). (Kenchington)

3. Complete sequencing of the 18S rRNA gene in selected molluscan species and publish the results. (Kenchington)

Incomplete. Five species of molluscs have been sequenced. In light of interesting results, four additional species have been added to the study and are currently being processed. (Kenchington)

4. Complete, to publication, the morphometric study begun in 1989/90. (Kenchington)

Incomplete. All morphometric data has been analyzed and image data has been analyzed by traditional methods. Delays have been encountered in programming more sophisticated analyses, but progress has been made. (Kenchington)

5. Analyze DNA/RNA in samples collected off Digby and continue monitoring program in 1991. (Kenchington)

All 1990 samples have been analyzed and presented both at ISAC meetings and the Digby Scallop Days booth. 1991 monitoring samples have been processed and partially analyzed.

6. Participate in Exploratory Fishing Program and evaluate data from the fishing logs. Expand the Bay of Fundy scallop cruises to include a survey of Brier Island in 1991. (Lundy)

Complete. Activities of the Exploratory Fishing Program have been followed. A research cruise was conducted on the Brier Island and Lurcher scallop stocks in August. These data have been analyzed and results presented to ISAC. (Lundy)

7. Prepare a video presentation on scallops for viewing by fishermen. (Kenchington)

Complete. A video was prepared and presented to fishermen at a meeting of OSAC (Halifax) and at the Digby Scallop Days display. (Kenchington)

8. Examine spatial variation in growth rate in the Bay of Fundy scallop stock. (Kenchington)

Complete. Spatial variation in growth rate has been analyzed and mapped. These results were presented to ISAC. Several hypotheses have arisen from this analysis and further data analysis coupling the growth results to RNA/DNA is ongoing. (Kenchington)

#### 4. Additional Accomplishments:

1. Initiated DFO representation at the Digby Scallop Days Festival in August, 1991. Co-ordinated and produced a Display Booth for the Festival.
2. Initiated bimonthly collection of scallop meats and shells for meat weight and RNA/DNA analyses through co-operation with one of the Digby scallop captains.
3. Attended ICES Benthic Ecology Meeting (Halifax) and invited to be a member of the working group.
4. Prepared a Manuscript Report on data collected on juvenile scallops at Sheet Harbour, NS (1990) and on surveys conducted by R. Mohn (1984-88).

#### 5. Goals/Expected Outputs for 1992:

1. Provide a stock assessment of the Bay of Fundy (Digby) scallop resource. (Kenchington)
2. Present biological advice to Inshore Scallop Advisory Committee. Prepare biologically based briefing documents when required and participate in other DFO sponsored activities pertaining to the resource management of scallops. (Kenchington)
3. Provide a stock assessment of Brier Island and Lurcher Shoal scallop resource. (Lundy)
4. Participate in Exploratory Fishing Program and evaluate data from the fishing logs. (Lundy)
5. Conclude 18S rRNA gene sequencing of the scallop and clam species, including data analysis and publication. (Roddick, Kenchington)
6. Complete morphometric study of scallop shells. (Kenchington)
7. Continue RNA/DNA monitoring program. (Kenchington)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

Image Analysis of Scallop Shells: Assoc. Prof. W.E. Full, Geology Dept., Wichita State University, Wichita, Kansas.

Genetic DNA Analysis of Marine Algae: C. Bird, Dr. M. Ragan, NRC, Halifax, Nova Scotia.

##### ii. University Liaison -

Image Analysis of Scallop Shells: Assoc. Prof. W.E. Full, Geology Dept., Wichita State University, Wichita, Kansas.

##### iii. Communications -

Digby Scallop Days Booth. Digby, Nova Scotia, August 1991.

##### iv. Contracts Administered -

Commercial port sampling activities for the Bay of Fundy fleet.

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Kenchington, E., C. Tetu, and R. Mohn. 1991. Preliminary investigations of juvenile scallops (Placopecten magellanicus) in Nova Scotia inshore habitats. Can. Manuscr. Rep. Fish. Aquat. Sci. 2123, 38pp.

Kenchington, E. and M.J. Lundy. 1991. 1990 Bay of Fundy Scallop Stock Assessment. CAFSAC Res. Doc. 91/26, 28pp. iv.

##### iv. Popular and Miscellaneous -

Kenchington, E. 1991. (Poster) The Use of RNA/DNA in Monitoring Scallops Stock Health. Digby Scallop Days, Digby, Nova Scotia.

Kenchington, E. and M.J. Lundy. 1991. (Poster) Scallop Abundance in the Bay of Fundy. Poster. Digby Scallop Days, Digby, NS.

Kenchington, E. and M.J. Lundy. 1991. (Poster) Fishing Logbooks: The Value of Logbooks in Scallop Management. Digby Scallop Days, Digby, N.S.

8. Review and Evaluation:

The project has a nice balance of assessment related duties and innovative research. Participation in the Digby Scallop Days provided an excellent opportunity to communicate fishery-related scientific programs to clients. The project leader should place some emphasis on the scallop morphometric study in an attempt to bring it to fruition.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 206

Section: Population Biology

Project Title: Cape Breton Crustacean Assessment and Research

Project Leader: Tremblay, J.

Other Researchers: Eagles, M. ; Miller, R.

Work Activity: W.A.1.1.1.3

Key Words: crabs; lobster; assessments; assessment research

1. Project Description:

This project conducts research, stock monitoring, and fisheries assessment of snow crab and lobster stocks on the Atlantic side of Cape Breton Island. Advice is also provided on other crab species as requested. The research commitment applies to all aspects of the biology and population dynamics of crabs and lobster ecology that will support crustacean assessment and management.

2. Long-Term Objectives:

Assess present and potential production of commercial crabs in the Scotia-Fundy Region and the possible effects of various management strategies; conduct research on all aspects of the life history, ecology, and environment of commercial crabs and lobsters relevant to understanding natural and man-induced fluctuations in stock size; develop methods of analysis and theoretical models for the above; and communicate results to industry, management, and science.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue biological monitoring of commercial snow crab in the Scotia-Fundy Region during 1991 and provide an assessment of the 1990 snow crab fishery to CAFSAC.

Completed. Port and sea sampling of the snow crab fishery completed. Presentations given at two snow crab advisory committee meetings (February and April). As a result of these meetings, fishermen in Area 23 voted to use a gauge on a trial basis for one year. CAFSAC did not require presentation of a 1990 assessment, but summary sheets were tabled.

2. Monitor the lobster fishery in LFA's 27-30, summarize the results and present to clients.

Completed. Port and sea sampling of the lobster fishery completed. A biological assessment presented to advisory committee meetings in December. Summary sheets of the lobster fishery in LFA's 27-30 were tabled at CAFSAC.

3. Details on new research projects will become available upon the staffing of a new crustacean scientist.

Since becoming project leader in April, J. Tremblay has reviewed the scientific literature, participated in port and sea sampling, and begun studies of: (i) snow crab fecundity, and (ii) changes in the geographic distribution of fishing effort in the snow crab fishery.

4. Additional Accomplishments:

Following requests from the Area Manager and Resource Allocation, provided advice on the snow crab fishery as follows: (i) the number of new licences which should be allowed in Area 24; (ii) a proposed offshore fishery; (iii) a proposed season extension. Advice also given on a proposed exploratory fishery for northern stone crab.

5. Goals/Expected Outputs for 1992:

1. Continue biological monitoring of commercial snow crab in the Scotia-Fundy region during 1992. Provide analysis of the effects of the experimental claw gauge to fishermen; table summary sheets of the snow crab fishery to CAFSAC. (Tremblay, Eagles)
2. Monitor the lobster fishery in LFA's 27-30, summarize the results and present to clients. (Tremblay, Eagles)
3. Complete manuscript report describing the lobster fishery database. (Tremblay, Hunter)
4. Produce report on the effect of logbook number on the precision of lobster CPUE estimates, and the ability to detect annual changes in CPUE. (Tremblay)
5. Produce preliminary report of seasonal and area differences in snow crab fecundity. (Tremblay)

6. Produce preliminary report of changes in the geographic distribution of snow crab effort since 1978. (Tremblay, Eagles)
7. Examine feasibility of obtaining estimates of growth and recruitment from juvenile surveys of snow crabs. (Tremblay, Eagles)
8. Assess the potential of an initiative to increase CL in LFA 27 stocks. (Tremblay)
9. To submit a long-term research proposal following monies provided in workplan. (Tremblay)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -  
See publications.
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -  
Beninger, P.G., R.W. Elner, and Y. Poussart. 1991. Gonopods of the majid crab *Chionoecetes opilio* (O. Fabricus). *J. Crust. Biol.* 11: 217-228.  
Elner, R.W., and A. Campbell. 1991. Spatial and temporal patterns in recruitment for American lobster, *Homarus americanus*, in the northwestern Atlantic. *Memoirs of the Queensland Museum* 31:xxx-xxx. Brisbane.
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -  
Eagles, M. and R. J. Miller. 1991. Summary sheets 1991- Lobster: LFA 27; LFA 28-29; LFA 30; Snow crab: Areas 2-4, Area 5, Area 6.. Presented to IMP Subcommittee of CAFSAC, Feb. 1991.

8. Review and Evaluation:

R. Elner left this project at the end of 1990 and publications based on his collaborative efforts continue. J. Tremblay became project leader in April, and several of the 1992 goals were begun under project 201. The transition between project leaders was effected smoothly and new initiatives are dynamically carried out.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 207

Section: Population Biology

Project Title: Marine Plants Assessment and Research

Project Leader: Sharp, G.

Other Researchers: Pringle, J.; Semple, R.

Work Activity: W.A.1.1.1.5

Key Words: marine plants; Irish moss; Chondrus; Ascophyllum; Laminaria; assessments;  
assessment research1. Project Description:

This project is an ongoing function dealing with research, monitoring and stock assessment of Maritime marine plant fisheries. Advice is given to a wide range of clients.

2. Long-Term Objectives:

To understand the relationship between marine macroalgal productivity and major abiotic and biotic variables; to determine the biological effects of long-term harvesting on marine plant productivity; to develop management models and harvesting strategies for the commercially important marine plant species in the Region; and to give sound stock assessment and biological advice to clients.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Compare alternate population models for Chondrus according to different recruitment processes. (Sharp)

Goal not met. Shelved for time being awaiting interaction with post doctoral fellow with expertise in modelling.

2. Assess Ascophyllum Resources in Scotia-Fundy and provide biological advice to management. (Sharp)

Goal met. Publication CAPSAC Res Doc:91/52. Provided advice to Resource Allocations Branch and the N.B. Department of Fisheries in the development of a management plan for Ascophyllum harvesting in N.B. Presentations to fishery managers, provincial agencies and industry groups.

3. Paper on the growth and mortality characteristics of a Chondrus population. (Sharp)

Goal not met.

4. Evaluate the productivity of Ascophyllum populations in southern New Brunswick. (Sharp)

Goal met. 27 sites sampled and analysis of samples 80% complete.

5. Initiate a study of life phase and frond condition indices for Chondrus crispus populations in southwest Nova Scotia. (Sharp)

Goal met. Technique development complete, sampling initiated.

4. Additional Accomplishments:

1. Completed assessment of St. Mary's Bay Ascophyllum stocks.
2. Initiated a study of the impact of harvesting on the population dynamics of Ascophyllum with 4 hand-harvesting methods and one mechanical method.
3. In conjunction with Land, Inventory, and Remote Sensing Institute (LIRS) acquired and analyzed satellite images of coastal New Brunswick to determine distribution of Ascophyllum resources.
4. Investigated and reported to the Director of Biological Sciences Branch, the causes for a severe build-up of storm-cast material on beaches in Lockeport Bay.
5. Investigated and made recommendations to the Director General on the condition of Dulse (Palmaria palmata) beds on Grand Manan Island following damage caused Hurricane Bob.
6. Carried out a consultancy for IDRC, which assessed a research proposal aimed at diversification of the Filipino seaweed industry. (Pringle)

7. Supervised Ph.D. student R. Santos. (Pringle)

5. Goals/Expected Outputs for 1992:

1. Assessment of Ascophyllum resources in Southwestern Nova Scotia. (Sharp)
2. Update the information on the abundance and distribution of New Brunswick Ascophyllum resources. (Sharp)
3. Evaluation of linear and non linear models for Chondrus population dynamics. (Sharp)
4. Develop an assessment and monitoring program for the Ascophyllum management plan in Southern New Brunswick. (Sharp)
5. Continue sampling Chondrus populations in SWNS for phase and condition indices. (Sharp)
6. Publish manuscript report on standing crop of Ascophyllum in N.B. (Sharp)
7. To co-chair a mini symposium on problems in the resource management of seaweeds, at the ISS., Brest, France. (Pringle)
8. To supervise Ph.D. student R. Santos. (Pringle)
9. To continue providing consultancy to IDRC on seaweed projects. (Pringle)

6. Background:

Highlights:

The marine plants program in Scotia Fundy has had a strong focus on Ascophyllum resources in 1991. The continuing high level of harvest in SWNS and the impending first time harvest in southern New Brunswick has created a heavy demand for resource information.

Selected Involvements:

- i. Collaborative Research -
  - With Dr. M.C. Mouchot of Canadian Center for Remote Sensing examined the use of a radar sensor for determination of algal coverage in the intertidal zone.
- ii. University Liaison -
  - Continued to serve on the Ph.D. committees of M. Lazo and R. Santos. (Sharp)
  - Consultations with R. Rangely, McGill University, M.L.H. Thomas, U.N.B., ecological impact of Marine Plant Harvesting.
  - Collaborated with Dr. T. Chopin, U.N.B. on chemical analysis of Chondrus populations.
- iii. Communications -
  - Provided biological expertise at three open houses on Ascophyllum harvesting in southern New Brunswick.
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
  - Sharp, G. and R. Semple. 1991. An Assessment of Ascophyllum nodosum resources in Scotia/Fundy. CAFSAC Res. Doc. 91/52, 30 p.
- iv. Popular and Miscellaneous -
  - Information sheets for public meetings on the biology of Ascophyllum nodosum.

8. Review and Evaluation:

A high level of interest in marine plant harvesting both in southwest Nova Scotia and southern New Brunswick monopolized a great deal of this project's resources; some planned activities (modelling, paper on Chondrus growth and mortality) had to be postponed. Answering the industry's need for resource information was a high priority. It is most important that this study place emphasis on the submission of publications in 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 208

Section: Population Biology

Project Title: Marine Plants Assessment and Research - Gulf Region

Project Leader: Sharp, G.

Other Researchers: Semple, R. ; Pringle, J. ; Jones, D.

Work Activity: W.A.1.1.1.5

Key Words: marine plants , Irish moss , Chondrus , wireweed Furcellaria , assessments  
assessment research1. Project Description:

This project is an ongoing function dealing with research, monitoring and stock assessment of marine plant fisheries in the Gulf of St. Lawrence. Advice is given to a wide range of clients.

2. Long-Term Objectives:

To understand the relationship between marine macroalgal productivity and major abiotic and biotic variables; to determine the biological effects of long-term harvesting on marine plant productivity; to develop management models and harvesting strategies for the commercially important marine plant species in the Region; and to give sound stock assessment and biological advice to clients.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide biological advice to resource managers and industry.

Goal met. Met with representatives of the industry and P.E.I. provincial government discussing project plans and needs of the industry.

2. Establish the infrastructure and support for a field research station. (Sharp)

Goal met. A former residence was converted into a field station with facilities for diving support, vessel maintenance, analysis of samples. It became operational in early April 1991.

3. Assess changes in marine plant communities in Marine Plant District 1 over the past eight years. (Sharp)

Goal met. All commercially important marine plant beds in district 1 and 2 were sampled over the harvesting season. Detailed benthic surveys were used to isolate and describe the populations in one bed with historical records of marine plant distribution.

4. Develop techniques to separate the effects, on abundance, of harvesting and environmental factors in commercially harvested Chondrus beds. (Sharp)

Goal met. A device was developed to enable protection of study areas from harvesting to separate environmental factors on growth and development of populations and this was incorporated successfully in experiments.

5. Initiate studies on the competitive interaction between Chondrus and Furcellaria in commercially harvested beds. (Sharp)

Goal met. Detailed studies were initiated on the spatial relationships between Chondrus and Furcellaria. The seasonal population structure and biomass of each species was monitored at permanent stations to determine recruitment patterns and reproductive strategies. Growth studies were initiated with the tagging of 600 fronds of each species.

6. Monitor catch effort and harvest characteristics in the Chondrus harvesting industry. (Jones)

Goal met. A project to monitor harvesting effort and the composition of the harvest was successful and was correlated with detailed landing records from each company.

7. Publish a paper on the density and biomass of Chondrus and the impact of harvesting. (Pringle)

Goal met. Paper in press in Canadian Journal of Fisheries and Aquatic Sciences.

4. Additional Accomplishments:

1. Provided advice to the industry on the design and results of a survey of Furcellaria resources in District 1.

2. Designed and completed an experiment to determine the short term impact of dragraking on Furcellaria abundance.
3. Assisted IDRC in design of a seaweed project in Senegal.

5. Goals/Expected Outputs for 1992:

1. Provide biological advise to the resource managers and the industry. (Sharp)
2. Provide an analysis of the long-term changes in marine plant communities in District 1. (Sharp)
3. Examine the marine plant beds of District 6 and determine if any significant changes have occurred in the last ten years. (Sharp)
4. Integrate information on nutrient status of Chondrus and Furcellaria with growth studies. (Sharp, Chopin)
5. Initiate competition experiments based on manipulation of density of Furcellaria and Chondrus. (Sharp, Têtu)
6. Evaluate effort and landing trends in the harvesting industry. (Jones)
7. Publish primary publication on the distribution of Furcellaria in District 1, P.E.I. (Sharp)

6. Background:

Highlights:

1991 was the first full field season for the Marine Plant Unit in the Gulf Region. A very strong and diverse field program was initiated with the assistance of a term biologist, summer students and technicians. Results are limited since this was the first year of the program.

Selected Involvements:

i. Collaborative Research -

Collaborative projects (mapping surveys, biomass estimates, growth, and reproduction) on Chondrus and Furcellaria commercial beds of western Prince Edward Island with the P.E.I. provincial government.

ii. University Liaison -

In collaboration with Dr. T. Chopin of U.N.B., Saint John campus, a project was begun to examine the seasonal nutrient composition of Chondrus and Furcellaria in conjunction with measures of productivity.

iii. Communications -

iv. Contracts Administered -

One contract from the Prince Edward Island Department of Fisheries to supplement the Marine Plants Unit program.

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Report on the "Development of red seaweeds in Senegal" in collaboration with A. Tamba and T. Chopin. Prepared for the International Development Research Centre.

8. Review and Evaluation:

Although just begun, this project is addressing significant issues of the marine plants harvesting industry.

Job well done.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 210

Section: Population Biology

Project Title: Lobster Stock Assessment (LFA 40-41) and Related Research

Project Leader: Pezzack, D.

Other Researchers: Duggan, D.

Work Activity: W.A.1.1.1.3

Key Words: lobster biology ; assessments ; assessment research ; LFA 40-41 ; stock structure ; offshore lobster

1. Project Description:

This project is an ongoing function dealing with: (i) monitoring and assessment of offshore lobsters on the Scotian Shelf, Gulf of Maine and Georges Bank (LFA 41); (ii) determination of the relationship between offshore and inshore lobster and the impact of offshore fishing activity on other areas; and (iii) research into the life history, ecology, and environment of lobsters relevant to understanding the natural and man-induced fluctuations in lobster stock size.

2. Long-Term Objectives:

Monitor the offshore lobster stocks, carry out research relevant in determining stock structure, and improve stock assessments in order to provide the best possible biological advice to clients.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Assess the offshore lobster fishery through logbooks, sales slips and at sea sampling programs. (Duggan)

Complete. Log books and sales slips coded (100% coverage) and catch, effort and C/E calculated. Four at sea samples taken and data coded. Summary Sheet prepared and presented to CAFSAC.

2. Communicate assessment and research results to the fishing industry. (Pezzack)

Complete. An update on assessment and research presented to Offshore Lobster Advisory Committee. Permission obtained from industry to publish previously confidential data on the offshore lobster fishery. Information communicated to fishermen through informal conversation while at sea or recovering tags in port.

3. Produce papers/reports on lobster distribution on the Scotian Shelf and Gulf of Maine; and structure in the Gulf of Maine; of offshore lobster movements. (Pezzack)

Incomplete. Lobster distribution paper is in draft form. Offshore tag release recapture data file closed (>20,000 records) and data edited in preparation for transfer to Oracle data base which will allow greater flexibility in analysis of offshore lobster movements. Offshore lobster growth paper, using tagging data, is being reviewed.

4. Examine the possibility of a collaborative project with J. Idoine to develop lobster population model, and to examine relationships between NMFS biomass estimates and actual trap CPUE. (Pezzack)

Incomplete. Model was not undertaken due to other commitments by both parties. NMFS trawl survey lobster by-catch data obtained.

4. Additional Accomplishments:

1. Coordinated, edited and senior author on Inshore/offshore lobster workshop report. (Pezzack)
2. Participated in Atlantic States Marine Fisheries Commission's lobster working group review of lobster assessment methods and methods of estimating fishing mortality (Woods Hole, Mass., July 9-10). (Pezzack)
3. Participant in ICES Benthic Working Group (Halifax, May). (Pezzack)
4. Assessed observer needs for invertebrate fisheries and met with MFD representatives to arrange sampling protocols. (Pezzack)
5. Presented Poster "Movement of offshore lobsters displaced to coastal areas of Nova Scotia" at National Shellfish Association meeting in Portland, Maine (July 26-28). (Duggan, Pezzack)

5. Goals/Expected Outputs for 1992:

1. Assess the offshore lobster fishery through log books, sales slips and at-sea sampling programs. (Pezzack, Duggan)
2. To communicate assessment and research results to the fishing industry. (Pezzack, Duggan)
3. Publication of: a) Inshore/offshore lobster workshop report (early 1992); b) Lobster distribution paper (early 1992); c) Offshore lobster growth paper. (Pezzack, Duggan)
4. Analyze offshore lobster tagging data base and prepare a publication on offshore lobster distribution and movements in the Browns Bank Area. (Pezzack, Duggan)
5. Compare NMFS trawl data biomass estimates and actual fishery catch rates. (Pezzack)

6. Background:

Highlights:

The offshore lobster fishery is a small but controversial fishery. Since 1986 reporting of fisheries data was prevented because there were only two participants in the fishery. Agreement was reached with industry at the recent Advisory meeting which will allow publication of detailed fisheries data and assessments at the next overall evaluation of the fishery.

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

Dr. Irv Kornfield, Coordinator, Lobster Institute, University of Maine, Orono, Maine - Planning a lobster modelling workshop for 1992.

iii. Communications -

iv. Contracts Administered -

Contract to conduct at sea sampling during June-August.

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Pezzack, D.S. and D.R. Duggan. 1991. LFA 41 Lobster CAFSAC Summary Sheet.

8. Review and Evaluation:

Assessment obligations are well fulfilled. Preparation of three important papers (report of the Inshore/Offshore Lobster Workshop, and papers on lobster distribution and growth of offshore lobsters) were the focus of the year under review. Another one, on offshore lobster movements, will now concentrate on the Browns Bank Area. It is most important that the project leader concentrate on the publication of findings following years of data collection from the offshore fishery.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 211

Section: Population Biology

Project Title: Lobster Habitat Research and Assessment Methodology

Project Leader: Miller, R.J.

Other Researchers: Nolan, S.; Roddick, D.

Work Activity: W.A.1.1.1.3

Key Words: lobster; assessment research; habitat research

1. Project Description:

The interdependence of near-shore marine communities and exploited species are investigated. Methods for stock assessment and increasing fisheries yields are developed.

2. Long-Term Objectives:

To assess the following: the impact of macrophyte removal on exploited species; the selectivity of crab and lobster traps, and the interdependence of inshore and offshore lobster stocks. To apply the results to fisheries management.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Submit manuscript (with R. Mohn) on the Leslie method of determining fish stock size. (Miller)

Goal met. Manuscript submitted to North American Journal of Fisheries Management.

2. Submit manuscript (with D. Roddick) on the conflict between inshore scallop gear and lobster fisheries. (Miller)

Goal met. Manuscript submitted to Canadian Journal of Fisheries and Aquatic Science.

3. Submit manuscript on lobster catchability coefficients. (Miller)

Goal met. Manuscript to be included in ICES Rapports et Procès-verbaux des Réunions.

4. Submit manuscript (with F. Watson) on spatial and temporal variation of lobster size at sexual maturity. (Miller)

Goal not met. Unscheduled time was spent on activities 4.1 and in collaboration with a visiting scientist.

5. Submit manuscript on the interdependence of benthic invertebrates (or juvenile fish) and macroalgae. (Miller)

Goal not met. Unscheduled time was spent on activities 4.1 and in collaboration with a visiting scientist.

6. Coordinate the lobster research program at the Halifax Fisheries Research Laboratory. (Miller)

Goal met. A manuscript on juvenile lobster habitat was co-authored with A. Campbell, G. Sharp, and C. Hudon. Several discussions were held with lobster scientists Pezzack, Tremblay, and Hudon on future directions for lobster research, and the inshore-offshore lobster problem. Research plans and results were exchanged at a meeting with D. Robichaud and P. Lawton from the St. Andrews Station. Lobster research directions were outlined for management.

7. Provide advice to industry and resource managers on crustaceans, sea urchins and nearshore habitat. (Miller)

Goal met. Fisheries management and the fishing industry were supplied with requested information on:

Sea urchins; harvesting methods, population distribution, population survey methods, gonad cycle, and the 1991-92 management plan.

Lobsters; movement, growth, reproduction, relationship of inshore and offshore stocks, trap design, and longevity of wooden traps.

Snow crabs; a new method for measuring legal minimum size (project initiated by R. Elner), location and number of additional snow crab licenses.

#### 4. Additional Accomplishments:

1. Initiated and supervised a touch tank of live marine animals located on the Halifax waterfront. The tank had 77,000 visitors between early June and early September, and was operated at a direct cost of \$.07 per visit. Salaries for students who manned the tank were obtained from Tourism Halifax and the Waterfront Development Corp. by J.D. Pringle.
2. Lobster larvae were sampled at 430 stations on the South Shore of Nova Scotia.
3. The distribution of egg bearing females on the South Shore of N.S. in the spring of 1991 was recorded with the help of fishermen.
4. Responsible for management advice on Cape Breton snow crab and lobster fisheries until April, 1991.
5. Gauges for measuring claw sizes of snow crab were developed for fishermen and biologists.

#### 5. Goals/Expected Outputs for 1992:

1. Make editorial changes required on manuscripts mentioned in 3.1 and 3.3 above.
2. Finish and submit manuscript mentioned in 3.4.
3. Review results of lobster larval sampling and collect a second year's data on fishermen's catches of egg-bearing females.
4. Continue advising on management of a new N.S. sea urchin fishery.
5. Continue as lobster research coordinator at the HFRL.
6. Assume responsibility for monitoring and advising on the LFA 33 lobster fishery.
7. Regional representative on DFO Science Subvention Committee.

#### 6. Background:

##### Highlights:

The success of the touch tank; the pleasure of working with a visiting scientist; communicating with diverse groups; finishing 3 years sampling of lobster larvae.

##### Selected Involvements:

##### i. Collaborative Research -

Sixty lobster fishermen on the South Shore of Nova Scotia were involved in a study of the location of egg-bearing females.

A joint experimental study was carried out with Dr. Julian Addison of the Fisheries Laboratory, Lowestoft, England, from September through December.

See also sections 3.1, 3.2, and 3.6 above.

##### ii. University Liaison -

Thesis committee of a Dalhousie M.Sc student and co-sponsor of an honours student.

##### iii. Communications -

Oral presentation to DFO, Scotia-Fundy economists: Good times licenses for limited entry fisheries.

Two oral presentations to lobster fishermen: 1) The strengths of S-F lobster regulations, 2) Lobster research on ovigerous females and larvae.

Oral presentation to fisheries officers: The strengths of S-F lobster regulations.

Two oral presentations to Cape Breton snow crab fishermen: 1) Stock distribution in southern Cape Breton, 2) A new measure of legal minimum size.

Worked with a writer on contract to Communications Branch to develop a brochure on shellfish biology and fisheries, and two Sou'Wester articles on shellfisheries management.

Interviewed by media on the topics of high lobster landings (MITV), the spatial relationship of navy target practice to lobster catches (CBC TV), prospects for a growing sea urchin fishery (Financial Times), relationship of lobster landings to fall storms (Queens County weekly)

Supplied information for two media releases and two Pisces articles on the touch tank.

##### iv. Contracts Administered -

##### v. Other -

Member of the organizing committee, the editorial committee, and chaired a session at the MEES

workshop on "Juvenile stages: the missing link in fisheries research".

7. Publications:

i. Primary -

Roddick, D. and R.J. Miller. 1991. Spatial and temporal impact of inshore scallop fishing on lobsters. Can. J. Fish. Aquat. Sci. (in press)

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Eagles, M. and R.J. Miller. 1991. Stock summary sheets presented to CAFSAC, IMP subcommittee: 1990 snow crab, Area 2-3-4; 1990 snow crab, Area 5; 1990 snow crab, Area 6; 1990 lobster, Area 27; 1990 lobster Areas 28-29; 1990 lobster Area 30.

Miller, R.J., A. Campbell, G. Sharp, and C. Hudon. 1991. (Abstract) Are small juvenile lobsters habitat limited? Abstract of paper presented at MEES workshop.

Miller, R.J. and F. Watson. 1991. (Abstract) Spatial and temporal changes in lobster size at maturity in Nova Scotia. Abstract of paper presented at the National Shellfisheries Assoc. Ann. Meet.

8. Review and Evaluation:

An exemplary year. A wide diversity of tasks accomplished. Several manuscripts have been submitted by the project leader and collaborators. Another well accomplished task was the evaluation and research planning for lobster resource science. Responsibility for biological advice on the LFA 33 lobster fishery is added to this project for 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 212

Section: Population Biology

Project Title: Lobster Resource Science - Larval Biology

Project Leader: Harding, G.C.; Pringle, J.

Other Researchers: Vass, W.P.; Duggan, R.; Miller, R.

Work Activity: W.A.1.1.1.3

Key Words: lobster; assessment research; larvae; recruitment

1. Project Description:

Studies designed to further understanding of lobster larval ecology and thereby the recruitment process of the American lobster through field studies and laboratory experiments.

2. Long-Term Objectives:

Provide scientific advice required to improve management of the lobster fisheries in the near-shore and offshore regions of Atlantic Canada based on results of research on larval lobster ecology, production, and recruitment.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Write and submit for primary publication manuscripts on: a) the vertical migration of lobster planktonic stages (Harding) and, b) the temporal and spatial distribution of lobster larvae in St. Margarets Bay, N.S. (Pringle)

Goals not met. Some progress has been made however:

- a) a paper was presented to the American Society of Limnology and Oceanography (meeting - June 10-14, 1991) (Harding);
  - b) a manuscript on lobster larval morphometrics from both the inshore and offshore has been through internal review (Harding); and
  - c) a paper was presented to the National Shellfish Association (June 23-27) demonstrating lobster larval dispersion off Georges Bank into the Gulf of Maine. (Harding, Pringle)
2. Submit a note for primary publication on the temporal and spatial distribution of lobster larvae in Jeddore Harbour, N.S. (Pringle)

Goal met. Technical report published and manuscript accepted for publication in Journal of Shellfish Research.

3. Submit for internal review, a manuscript on the spatial distribution of the planktonic lobster life history stages in relation to Georges Bank. (Harding)

Goal not met.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Write and submit for primary publication manuscripts on: a) the vertical migration of lobster planktonic stages (Harding) and, b) the temporal and spatial distribution of lobster larvae in St. Margarets Bay, N.S. (Pringle)
2. Submit for internal review, a manuscript on the spatial distribution of the planktonic lobster life history stages in relation to Georges Bank. (Harding)
3. Prepare a manuscript on the evidence for lobster larval dispersal from Georges Bank. (Harding)
4. Conduct a study to track the dispersal of lobster larval patches from NW Browns Bank using Loran-C drifters and Vass-Tucher trawl. (Harding)

6. Background:

Highlights:

## Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Papers presented at the ASLO and NSA meetings. (Harding)

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

DiBacco, C. and J.D. Pringle. 1991. Larval lobster (Homarus americanus Milne Edwards) distribution in a protected Scotian Shelf bay. Can. Manuscr. Rep. Fish. Aquat. Sci. 2110: 26pp.

iv. Popular and Miscellaneous -

Harding, G.C., J.D. Pringle, K.F. Drinkwater, A.J. Fraser, I.R. Perry and W.P. Vass. 1991. Offshore studies of larval lobsters (Homarus americanus) in the Georges and Browns Bank region. Abstract, National Shellfish Association, meeting, Portland, Me., June 23-27, 1991.

8. Review and Evaluation:

The full analysis of the results of this project are important to future planning of the overall lobster research program. Until such analysis is completed and submitted for publication, no new field work should be initiated.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 213

Section: Population Biology

Project Title: Lobster Resource Science and Assessment - LFA 31 and 32

Project Leader: Pringle, J.

Other Researchers: Duggan, R.

Work Activity: W.A.1.1.1.3

Key Words: lobster; assessments; LFA 31-32; assessment research

1. Project Description:

Ongoing assessment of the lobster fishery along Nova Scotia's eastern shore, developing assessment techniques, carrying out resource science, providing biological advice to industry and the resource manager.

2. Long-Term Objectives:

To provide the best possible advice on which to base sound lobster management by employing the most efficient methods for gathering and analyzing stock assessment data and by carrying out pertinent research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Assess the lobster stocks in LFA 31-32 and provide biological advice to the resource manager and industry. (Duggan)

Goal met. Meetings attended and biological advice presented (see Publications). Data were presented on CPUE, and characteristics of lobsters within the catch. Biological advice presented in support of the current management plan's levels of effort and exploitation rates.

2. Write and submit a manuscript on aspects of lobster reproductive ecology. (Pringle)

Goal not met. Effort placed elsewhere.

3. Provide biological advice, via CAFSAC, on lobster growth and dispersion in the southern portion of LFA 32. (Pringle)

Goal not met. Effort placed elsewhere.

4. Give advice on the impact of season on tagging results. (Duggan)

Goal not met. Effort placed elsewhere.

5. Assist and supervise graduate student R. Ugarte. (Pringle)

Goal met. R. Ugarte passed his admittance-to-candidacy exam (see publications) and initiated research in the Canso area on the ecology of egg-bearing female lobsters. The study involves an assessment of embryo development in relation to local physical conditions. Fishermen play a key role in this study. A field station was set up in Canso and experimentation continues from May through December.

4. Additional Accomplishments:

1. Supervised BSc. Honours student Taja Lee's thesis, "Molting and mating behaviour in Homarus americanus, a field experiment." Lobster molting and mating behaviour has previously only been studied in the laboratory. This study employed cage-held lobsters placed in the wild. The study has confirmed observations made in the laboratory regarding the role of males in the protection of post molt females. It was also shown that dominant females will cannibalize subordinate, early post-molt females.
2. Co-edited (with Dr. S. Cobb) two issues of The Lobster Newsletter (TLN).
3. Co-organized (with Dr. L. Incze) a mini symposium, at the NSA conference, on current issues in lobster resource science. See TLN 3(2) for conclusions.
4. With co-author L. Burke, revised chapter on lobster management for S. Parsons' book on Canadian Fisheries Management. Now accepted for publication.

5. Goals/Expected Outputs for 1992:

1. Assess the lobster stocks in LFA 31-32 and provide biological advice to the resource manager and industry. (Duggan)
2. Write and submit a manuscript on aspects of lobster reproductive ecology. (Pringle)
3. Provide biological advice, via CAFSAC, on lobster growth and dispersion in the southern portion of LFA 32. (Pringle)
4. Give advice on the influence of tagging data on tag retention. (Duggan)
5. Assist and supervise graduate student R. Ugarte and Honours BSc. student T. Lee.
6. Co-edit The Lobster Newsletter.

6. Background:

## Highlights:

## Selected Involvements:

## i. Collaborative Research -

## ii. University Liaison -

Co-supervising graduate students R. Ugarte and R. Santos with Dalhousie University Biology Department faculty. (Pringle)

## iii. Communications -

Seminar prepared by student R. Ugarte for presentation at Dalhousie University on the impact of temperature on embryo development in lobsters.

Presented the annual stock assessment to LFA 31/32 advisory committee. (Pringle)

Interpretation of video on lobster trapping to fishermen of Canso area. (Duggan)

Chaired the Round Table Discussion at the NSA Conference on lobster ecology and resource science. (Pringle)

## iv. Contracts Administered -

Personal service contract with Dr. R. O'Dor.

## v. Other -

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

Volume 3 (1&2). The Lobster Newsletter, with coeditor J.S. Cobb.

Annual stock assessment - LFA 31/32, 8pp.

Behaviour and ecophysiology of late-stage female lobsters [Homarus americanus (Milne-Edwards)] along Nova Scotia's eastern shore. Research proposal by R. Ugarte.

Molting in Homarus americanus; A field experiment. BSC Honours thesis proposal submitted by T. Lee.

8. Review and Evaluation:

This ongoing project is progressing well. The contacts with the fishing industry are well-developed, and the cooperative research project, with students at Dalhousie, enriches the scope of the work.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 214

Section: Population Biology

Project Title: Lobster Assessment and Related Research in LFA 34

Project Leader: Pezzack, D.

Other Researchers: Duggan, D.; Hudon, C.

Work Activity: W.A.1.1.1.3

Key Words: lobster biology ; assessments ; assessment research ; LFA 34 ; stock structure ; inshore lobster ; Gulf of Maine ; Southwest Nova Scotia

1. Project Description:

The project has the ongoing functions of: 1) monitoring the lobster fishery in LFA 34; 2) advising on management, and 3) carrying out research relevant to understanding population dynamics and assessment methods.

2. Long-Term Objectives:

To provide and promote advice and carry out research relevant to improving stock assessments leading to improved management.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Monitor the lobster fishery in designated ports in LFA 34 and summarize results for management and industry. (Duggan)

Complete. Annual sampling and collection of logbooks completed, and data coded. Summary sheet of LFA 34 fishery prepared and presented to CAFSAC, and update of fishery presented to the LFA 34 advisory committee.

2. Provide biological advice on management related issues at the LFA, and Regional and Zonal levels. (Pezzack)

Complete. Provided advice to management on biological bases of lobster trap limits in LFA 34, and the need for a review of the limit. Compiled lobster summary sheets for Scotia-Fundy and for CAFSAC. Provided advice on minimum sizes to managers, and researchers in Economics branch.

3. Present paper on the voluntary logbook system to CAFSAC SSSS (Statistics, Sampling and Survey Subcommittee) for review and assessment of methodology. (Pezzack)

Complete. CAFSAC working paper presented with M.J. Tremblay, to CAFSAC SSSS. The subcommittee examined design, uses and problems in voluntary logbook systems and made comments on further analysis.

4. Investigate the possibilities of a multi-year project to assess seasonal levels and distribution of lobster fishing effort in the 'midshore' (25-50 miles) areas of LFA 34 using remote sensing and the interview technique. (Duggan)

Complete. Conducted flights over the midshore area on an opportunistic basis using the DFO helicopter. Determined the geographic extent of inshore effort, but no quantitative estimates of effort were made. No surveys were undertaken due to budget and overtime restraints.

5. Carry out NOS VE conversion of lobster programs. (Duggan)

Completed.

6. Continue work on improving accessibility to lobster fishery data by incorporating length frequency data into Oracle Database. (Pezzack)

At-sea sample data for LFA 34 was prepared and edited; to be incorporated into length frequency data base. The data was entered and analyzed with existing size frequency programs.

4. Additional Accomplishments:

1. Participated in special lobster workshop at National Shellfish Association meeting in Portland, Maine (July 27). (Pezzack)
2. Participated in workshop discussion on lobster research at Maritimes Fishermen Union Annual

meeting (Yarmouth Feb. 16). (Pezzack)

3. Initiated literature search of information on lobster predators as part of investigations into the cause of the lobster recruitment pulse in the 1980's. (Pezzack)
4. Provided information on lobster fishery and the biological basis of trap limits to the Crown Prosecutor in a case involving fishermen exceeding the trap limit. (Pezzack)
5. Participated in CAFSAC-MESS Workshop on Juveniles Stages and Fisheries (Halifax Oct. 1-2). (Pezzack)
6. Tagged berried female lobsters in Barrington Bay (May) to determine movements and usefulness of site for future research. (Duggan)
7. Monitored bottom temperatures at a monitoring site established in Pubnico Harbour and Barrington Bay. (Duggan)
8. Met with Clearwater Lobster representatives, reviewed their scientific sampling proposal and established the protocol for fulfilling the requirements of a scientific permit to sample lobsters for molt stages during the LFA 34 closed season in 1992. (Pezzack)
9. Modified and tested a yield/recruit program to generate estimates of population size structure information for Economics Branch study of the effects of increases in minimum sizes. (Pezzack)

#### 5. Goals/Expected Outputs for 1992:

1. Monitor the LFA 34 lobster fishery by sampling the catch at sea, and using a voluntary logbook program in designated ports in LFA 34, and summarize results for management and industry. (Duggan, Pezzack)
2. Provide biological advise on lobster management and related issues at the LFA and regional and zonal levels, and coordinate production of CAFSAC summary sheets into document for public. (Pezzack)
3. Coordinate a review of - 1) purpose and expectations of voluntary logbook information; and 2) logistic requirements (quantity, deployment within and between LFA) of voluntary logbook data collection. (Pezzack)
4. Estimate recent changes in midshore effort, using flights of opportunity on DFO helicopter and interviews with fishermen. (Duggan, Pezzack)
5. Oversee the monitoring lobster molting period(s) at two sites in LFA 34 using pleopod and blood protein methods. Sampling and analysis to be done by Clearwater Lobsters, under a scientific permit. (Pezzack)
6. Tag berried females during late May, in Barrington Bay to determine over wintering grounds. (Duggan, Pezzack)

#### 6. Background:

##### Highlights:

Inshore lobster landings continue to increase and in many areas are at or near all time records. Many requests were made by industry, press, scientists, and managers for an explanation of the explosion in landings. Though scientists have been unable to explain it, the wide spread nature (Quebec-Mass.) suggests an environmental mechanism. Initiated work to examine potential causes including predation and temperature.

##### Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
  1. Interviewed by press for information/article/broadcast -Portland Press Herald, Portland Maine (Jan.30), CBC-TV (April 10 and Dec. 19), Globe and Mail (S. Strauss May 3), Daily News, Halifax (May 7), Seafood Newsletter, Seattle Wash. (Sept. 9), Broadcast News (Nov.6), Saint John Telegraph Journal (Nov. 27); CBC Radio (Dec. 3). (Pezzack)
  2. Responded to many enquiries from fishermen and public on lobsters and the state of the stock. (Pezzack)
  3. Staffed the DFO booth at the Lunenburg Fisheries Exhibition (August) and provided biological expertise to queries from visitors. (Duggan)
- iv. Contracts Administered -
  - Tag recovery contracts to agents in Port Hebert and Port Maitland to recover tags.
  - Contract to conduct at sea sampling during spring and fall season.

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Pezzack, D.S. and D.R. Duggan. 1991. LFA 34 Lobster CAFSAC Summary Sheet.

8. Review and Evaluation:

Although considerable impromptu demands were made upon investigators's time, they managed to fulfil their assessment obligations and continued projects to improve the quality of advice they provide (adequacy of voluntary logbook system, accessibility of lobster fishery data). The project leader is nicely filling his role as Branch lobster coordinator.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 220

Section: Informatics and Administrative Services

Project Title: Statistical Consulting

Project Leader: Rodger, R.

Other Researchers:

Work Activity: W.A.1.1.1.3

Key Words: statistical analysis; sampling; experimental design

1. Project Description:

Collaborate with and advise other researchers on projects requiring experimental design and/or statistical analysis and modelling.

2. Long-Term Objectives:

To act as the mathematical and statistical consultant for the Benthic Fisheries and Aquaculture Division. To provide advice on appropriate techniques used in the assessment and research of benthic populations and develop sound sampling techniques and experimental design.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

New Project. No goals were established last year.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Collaborate with and advise other researchers on projects requiring experimental design and/or statistical analysis and modelling.
2. Assisting Dr. J. Castell in the design and analysis of his experiment on various dietary equivalents for lobsters and their attractant properties.
3. Assisting J. Kean-Howie in the analysis of her data on nutritional requirements of lobsters.
4. Assisting Dr. R. Miller in the design, analysis and interpretation of his experiments on the effect of "strangers" and of local population density on the capture rate of crabs.
5. Advising B. Jessop on the analysis and interpretation of his data on fecundity in anadromous alewives and blueback herring.
6. Assisting Dr. C. Hudon in her analysis of the advection of lobster in Iles de la Madelaine.
7. Assisting K. Freeman in the analysis and interpretation of his data on condition indices for mussels.
8. Advising R. Santos on the analysis and interpretation of his data on the distribution of seaweeds.
9. Advising Dr. Tremblay on sample-size and power for his data on assessment of catch.
10. Advising R. Ugarte in the analysis and interpretation of his data on the colony of berried females and experimental design of laboratory studies.
11. To advise T. Lee (Honours BSc) on the analysis and interpretation of his data on lobster molting and sexual behaviour.
12. If time and priorities permit, plan and implement a workshop on multiple contrasts, power and sample size.

6. Background:

Highlights:

**Selected Involvements:**

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

**7. Publications:**

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

This new project began the last quarter of 1991. The concept was to employ a mathematician who was happy to contribute to the success of others' research, while doing little personal research. From all reports, we chose wisely and the project is off to a great start.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 225

Section: Population Biology

Project Title: Section Administration

Project Leader: Robert, G.

Other Researchers:

Work Activity: W.A.1.1.1.3

Key Words: administration

1. Project Description:

The Section is responsible for providing biological advice on the management of commercially important invertebrate and marine plant resources and carry out research deemed to improve the biological advice. Administrative and scientific leadership is provided to Section personnel.

2. Long-Term Objectives:

Provide an environment conducive to high quality biological advice and excellent science given the resources available. Provide accurate and timely administration.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. The provision of accurate and timely biological advice by Section staff, in a manner comprehensible to the client.

Section staff have attended numerous meetings of pertinent Advisory Committees, ad hoc meetings dealing with local issues of multi-resource usage, environment, and habitat. They have also participated in sessions on the Halifax Harbour Clean-Up, jurisdiction of the marine plants resource and a Scallop Science Day. They were involved as DFO representatives at the Yarmouth and Lunenburg Fishery Exhibitions and the Digby Scallop Days.

2. Scientific projects that are deemed most important to improve biological advice.

A review of lobster resource science has been completed to establish directions with respect to inshore-offshore and other pertinent questions. An overtime budget allocation scheme was developed so that projects get adequate coverage according to needs.

3. To provide opportunities for development and temporary assignment to section personnel and fill present section PY vacancies with the best individuals available.

Section personnel were provided with opportunities for development by scientists visiting the Halifax Laboratory: Julian Anderson, MAFF, Lowestoft, crustacean trapping behaviour; Put Ang, University of British Columbia, marine plants population modelling; and Peter Beninger, Université de Moncton, snow crab reproductive physiology.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. To provide leadership in the management of all Section resources.
2. The provision of accurate and timely biological advice by Section staff, in a manner comprehensible to the client.
3. That the scientific project carried out are those deemed most important to improve biological advice.
4. To provide Section personnel with opportunities for career development.
5. To assist in the management of both the Division and Laboratory, and in 1992-93, to provide advice on choosing a creative mechanism for allocating meagre O&M resources.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Section personnel were approached on many occasions to provide scientific background information to journalists in charge of articles for fishery trade publications (scallop, lobster, marine plants, etc).

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Ginette has been stalwart in budgeting Section fiscal resources in a year of tight monies. She is now familiar with Section programs and more comfortable and confident in the role of Section Head. Despite personal illness, she has met most deadlines and assisted with Division matters. The coming fiscal year will require the development and deployment of concepts, hitherto untried, to satisfy project leader's fiscal expectations and meet the Section's mandate.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 226

Section: Division Chief/Laboratory Director

Project Title: Division/Laboratory Administration

Project Leader: Pringle, J.

Other Researchers: Field, B. ; Covey, M. ; Shellnutt, S. ; Wentzell, C.

Work Activity: W.A.1.1.2.1 ; W.A.1.1.1.3 ; W.A.1.1.2.3

Key Words: administration ; planning

1. Project Description:

The Division has three equally important, areas of responsibility, all of which involve the provision of biological advice: first, Regional (excluding the Bay of Fundy) stock assessment advice is provided on commercially important, invertebrate and marine plant resources; secondly, advice is provided on the disease and nutrition of commercially important finfish and invertebrate species; and thirdly, advice is provided on those species of invertebrates important to aquaculturalists along the southern and eastern shores of Nova Scotia. Division personnel carry out that research deemed most important to upgrade the advice. This project is responsible for ensuring that Division personnel have sound scientific leadership and that the HFRL provides good administrative support for all occupants.

2. Long-Term Objectives:

Maintain a Division whose scientific personnel provide the best possible biological advice to clients, and conduct the research most pertinent for improving the quality of advice given. Maintain the best possible research environment for laboratory personnel that available resources can provide. Maintain an administrative team that provides the best possible service to scientific personnel and completes administrative tasks in a timely and accurate fashion.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. To ensure the Division is financially solvent through the fiscal year.

Goal not met. The Division Chief extended budget expenditures to accommodate what were deemed necessities. Additional monies were required to complete a room to accommodate new microscopic equipment. Facilities Management could contribute nothing to its actual construction. The Division Chief chose to construct the room. Other unexpected costs resulted in a deficit situation in January, 1992.

2. To ensure the Division meets its administrative and advisory responsibilities in a timely and professional manner.

Goal met.

3. To ensure significant improvements in the publishing record of certain Division members.

Goal partially met. Steps taken were successful in two cases, but were unsuccessful in another.

4. To assess, and where deemed appropriate, implement the recommendations of the reviews on disease research and diagnostics and lobster research.

Goal partially met. Monies were scavenged to support a PDF in disease research, but resources were unavailable to do more. The offshore/inshore lobster research assessment is yet unavailable.

5. To organize and/or chair meetings, both of the Division Management Committee and Staff, and attend meetings of the Building Management Advisory Committee, Tuesday Club, Branch Advisory Committee and others as arranged.

Goal met. Meetings were attended and/or chaired and contributions made. Chair of the Lab Management Advisory Committee was transferred to the Division's Administrative Assistant. About six laboratory staff meetings were held and deemed successful by lab personnel.

6. To take a course in science leadership (possibly at the Canadian Center for Management Development).

Goal not met. Cancelled due to insufficient funds.

7. To perform the duties of Core Member of the CAFSAC Invertebrates and Marine Plants subcommittee.

Goal partially met. Attended one meeting, but sent a substitute to the other.

4. Additional Accomplishments:

1. Encouraged the development of the successful "touch tank" by soliciting operating expenses from both the City of Halifax and the Halifax Waterfront Development Corporation.
2. Organized with J. Castell, a DFO sponsored fund raiser for the Schizophrenic Society of Nova Scotia.
3. A review of Dr. J. Castell's longterm research proposal was organized and acted upon. John will be moving into the field of lipid nutrition with emphasis on candidates for groundfish aquaculture.
4. Innovative plan put in place to use a one-half time, FTC py to hire a much needed mathematician.

5. Goals/Expected Outputs for 1992:

1. To ensure the Division is financially solvent through the fiscal year.
2. To develop a unique plan for the funding of stock assessment and resource science projects based on an O&M budget insufficient to continue the use of past practices in the dispersion of monies.
3. To ensure the Division meets its administrative and advisory responsibilities in a timely and professional manner.
4. To ensure significant improvements in the publishing record of certain Division members.
5. To organize and chair meetings, both of the Division Management Committee and Staff, and attend meetings of the Building Management Advisory Committee, Tuesday Club, Branch Advisory Committee and others as arranged.
6. To take a course in science leadership (possibly at the Canadian Center for Management Development).
7. To perform the duties of Core Member of the CAFSAC Invertebrates and Marine Plants subcommittee.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

In spite of the budget difficulties in 1991, the administrative functions at the Halifax Laboratory have been handled well. Morale is very good and is due, in part, to the communication efforts of the Laboratory Director.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 229

Section: Population Biology

Project Title: Wild Mussel Resource Assessment and Research

Project Leader: Sharp, G.

Other Researchers: Semple, R.

Work Activity: W.A.1.1.1.3

Key Words: mussels; assessments; assessment research; Mytilus edulis; lobster1. Project Description:

This is an ongoing project concerned with stock assessment, research and the provision of biological advice on the Region's wild mussel harvest.

2. Long-Term Objectives:

Determine the distribution and resource characteristics of wild mussel stocks; describe and assess the developing mussel harvest industry and its impact on the resource and associated species; develop management models and strategies for the resource; and provide clients with resource information.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Monitor and assess the fishery. (Sharp)

Goal not met. This fishery was not active in 1991.

2. Publish the results of side scan sonar and abundance survey. (Sharp)

Side scan sonar results were published separately as a report of the Geological Survey of Canada. Abundance information will be correlated with the distribution of substrate type.

3. Examine earlier survey samples for 'new' mussel species (Mytilus trossulus) identified in aquaculture research. (Sharp)

Goal not met.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Unless this fishery becomes active in 1991, assessment will not be carried out.
2. Examine samples previously collected for the presence of a 'new' mussel species (Mytilus trossulus) that has been found in aquaculture research.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The lack of activity in this particular fishery prompted the project leader to focus on other Divisional projects that required more attention.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 235

Section: Population Biology

Project Title: Resource Mapping and Special Projects

Project Leader: Black, G.

Other Researchers: Robert, G., Branton, R., Hunter, C.

Work Activity: W.A.1.1.1.3

Key Words: resource surveys; mapping; data processing

1. Project Description:

Conducts the Branch Resource Mapping Program. Undertakes projects requiring specialized computer graphics skills and methods, and provides support to other projects with mapping or computerized graphics requirements.

2. Long-Term Objectives:

Provide a vehicle in which the Branch's research results will receive wider distribution in support of the DFO goal of increasing the visibility of the Science Sector programs.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Conduct work toward additional publications on aquatic resources in the special publication series initiated with the squid and scallop publications. The subject may be cod, herring, or some other branch research area. Final determination of the subject matter has yet to be determined. (Black)

Goal not met. Postponed pending the completion of the scallop resource atlas. This publication is now scheduled to be published early in 1992.

2. Extend the graphics software program ACON to include support for 3D visualization, iconic tool sets, ORACLE access, presentation of variance estimates, and vector/matrix operators. (Black)

Goal partially met. ACON now supports 3D visualization, and ORACLE access. Other features added, superseded implementation of the additional planned enhancements.

3. Participation in the 5ze scallop assessment as required. Document existing assessment techniques used more fully. (Black)

Goal met. Participated in the 5zc Scallop assessment.

4. Improve the interface and documentation for the Graphical Tuning Assessment software. (Black)

Goal partially met. An enhanced graphic stock projection and VPA were implemented.

5. Improve the interface for the VAX version of ACON, and implement PC compatible version (with COGS). X Window System implementation (with consultant). (Black)

Goal partially met. Updated versions of ACON were ported successfully to the St. Andrews VAX, BIO Cyber, and PCs. The X Window version implementation was not attempted.

6. Research and analysis as mandated by line management during the year. (Black)

Goal met. Conducted analysis and development as required on other collaborative projects.

4. Additional Accomplishments:

The project leader continued to be involved in unplanned related work which impacted the completion of expected outputs. (support role to users of sophisticated graphical packages; development of software modules in C and object-oriented languages where the project leader has superior technical expertise)

5. Goals/Expected Outputs for 1992:

1. If the Atlas publication series is continued, conduct work toward an additional publication. The subject may be cod, herring, or some other Branch research area. Final determination of the direction has yet to be determined. (Black)
2. Extend the graphics software program ACON to include support for interprocess communication,

presentation of variance estimates, and vector/matrix operators. (Black)

3. Participate in the 5zc scallop assessment as required. Document existing assessment techniques used more fully. (Robert, Black)
  4. Improve the interface and documentation for the Graphical Tuning Assessment software. (Black)
  5. Support the VAX and PC implementations of ACON as directed. (Black, Branton)
  6. Integration of Lobster and Scallop databases and ACON using imbedded SQL scripts for automated graphical analysis. (Black, Hunter)
  7. Research and analysis as mandated by line management during the year. (Black)
6. Background:

Highlights:

Participation in the 5zc scallop assessment remained a challenging task for this review period.

ACON has proved successful in providing the required functionality to fill a number of application niches not currently supported by commercial software. Development of this tool will continue as necessary to meet new requirements for scientific visualization when appropriate.

Selected Involvements:

i. Collaborative Research -

R. Mohn, M.F.D.: refinement of assessment techniques using interactive graphics.

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This year will likely witness the publication of the scallop atlas. Important graphical developments came to full deployment during the review period (high degree of versatility and portability of ACON; graphic tuning interface). Such specialised graphic skills are a significant asset to the Biological Sciences Branch.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 241

Section: Aquaculture

Project Title: Administration - Aquaculture Section

Project Leader: Scarratt, D.

Other Researchers:

Work Activity: W.A.1.1.2.1; W.A.1.1.2.3

Key Words: administration; data processing

1. Project Description:

Manage administration of research and service unit comprising 16 PYs and \$256K.

2. Long-Term Objectives:

Overall effective management of section programs within budget allocations.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide effective administrative and scientific leadership to the section. Emphasis will be placed on bringing a backlog of data to publication stage. (Scarratt)

Goal partially met. There are yet research personnel who have not resolved their backlog of unpublished work.

2. Contribute to Division and Laboratory leadership. (Scarratt)

Contribution effective. Morale within the section is high notwithstanding budget and staffing constraints. Successful applications were made to AFAP for additional funding in the early part of the year, although success has been less marked latterly with the determination that federal labs are not eligible for AFAP research funding. A successful joint venture was arranged with Seafarm Canada for an additional technician in the Fish Health Unit.

3. Review format and organize the 14th Regional Fish Health Workshop. (Scarratt)

The 14 Regional Fish Health Workshop was held successfully in Halifax, November 7 - 8, 1991. There were 140 registrants. 32 papers were presented. A special session was held on Amendments to Fish Health Protection Regulations.

4. Co-chair the Laboratory Safety Committee. (Scarratt)

This committee meets regularly and contributes significantly to the awareness of safety issues among the staff. Nevertheless, inadequate funding has resulted in many safety issues remaining unaddressed or unresolved.

5. Coordinate reviews of lease and permit applications for Branch (Project 247 1989/90). (Scarratt)

Forty-five applications for aquaculture leases reviewed to mid-November 1991. Five ACOA applications received and evaluated. Three AFAP applications received and evaluated.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Provide effective administrative and scientific leadership to the section. Emphasis will be placed on bringing a backlog of data to publication stage. (Scarratt)
2. Contribute to Division and Laboratory leadership. (Scarratt)
3. Review format and organize the 15th Regional Fish Health Workshop. (Scarratt)
4. Co-chair the Laboratory Safety Committee. (Scarratt)
5. Coordinate reviews of lease and permit applications for Branch (Project 247 1989/90). (Scarratt)

6. Background:

**Highlights:**

Highlights have been somewhat mixed. The loss of a technical position in Histology has only partially been made up by a combination of student and part time positions. This will curtail production of the Cod Atlas and delay re-orientation of that program. There is a chronic lack of operating funds as evidenced by the inability within the Section, Division, or Branch to provide adequate funding for reconstruction of the microscope suite, and other outmoded laboratories.

The budgetary constraint on the working of overtime has exacerbated the problems of maintaining adequate care of experimental animals over weekends and on Holidays.

**Selected Involvements:**

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

With Darcel Williams: To provide assistance in the transfer of Phage Typing technology from the Research Unit to the Diagnostic Unit. Funding from AFAP, A Base funds, and Seafarm Canada.

With Mallet Research Services: To provide electrophoretic analysis of Mussel populations in Atlantic Canada. Funding from AFAP.

v. Other -

**7. Publications:**

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

For the second successive fiscal year the section experienced significant budgetary problems in the last quarter. This was inspite the Section Head's success in attracting some outside monies during 1991/92. In part, the problem was exacerbated by the acquisition of a much needed PDF in disease research and the assistance given to the construction of an electron microscope suite. For fiscal year 1992/93 the section must, via the Workplan exercise, develop fiscally sound priorities. The Section Head has done a great deal in the promotion of aquaculture, witness his successful organization of the annual Fish Health Workshop. Dave has often given wise council to the lab Director and has done an exemplary job in promoting lab safety.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 242

Section: Aquaculture

Project Title: Invertebrate Nutrition

Project Leader: Castell, J.

Other Researchers: Boston, L.

Work Activity: W.A.1.1.2.3

Key Words: lobster; nutrition; scallops; aquaculture; marine fish; algae; lipids; essential fatty acids; metabolism

1. Project Description:

The nutritional requirements of marine invertebrates are studied by conducting feeding trials using diets varying in one or more specific nutrients such as vitamins, lipids, or amino acids and by using radio tracers and short-term physiological studies. The growth, survival, metabolism, feed conversion, and other indices of nutritional quality are monitored.

2. Long-Term Objectives:

Establish the nutritional requirements of important marine invertebrates such as lobsters, scallops, and oysters; determine the nutritional composition of locally available raw materials that could be used in formulated diets; formulate nutritionally adequate, economical feeds for use in lobster and other marine invertebrate research and culture; and acquire a basic understanding of the role of essential nutrients in the metabolism and physiology of marine invertebrates.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Scientific Publications. A special effort will be devoted to completion of several outstanding manuscripts including: Protein/Energy requirement studies with Homarus americanus, Astacus astacus, Penaeus orientalis (Castell); Nutritionally induced molt death syndrome studies (Castell); Crustacean Feed Attractants Review (Castell); Essential fatty acid studies with Homarus americanus and Penaeus orientalis (Castell).

Goal partially met. A paper on the protein/energy (P/E) ratio of diets for Astacus astacus has been accepted for publication in Aquaculture, a second P/E paper is in draft form and two others are in outline. The review of feed attractants has not yet been written. The papers on essential fatty acid (EFA) requirements will be based on the research of two Ph.D. candidates.

2. Laboratory Studies: Commence collaborative studies with other scientists in the Halifax, DFO, Laboratory on the importance of lipids in larval fish, crustacean and/or mollusc nutrition. (Castell)

Goal partially met. Collaborative projects have been initiated with the Halibut culture project in St. John's Newfoundland (Dr. Joe Brown and Dr. Greg Goff), and with Dr. Robert Miller to evaluate the possibility of using distinctive fatty acid composition patterns to distinguish lobster eggs or larvae from offshore stocks.

3. Develop a long-term research plan in a broad area that has been agreed upon through discussions with Section Head and Division Chief.

Goal met. A detailed 5 year proposal for research into nutritional requirements of non-salmonid fish species was completed and has been reviewed by an administrative committee (October 30, 1991). This in turn has led to a branch-wide review of aquaculture research projects and is reflected in the program outlined in 5 below.

4. Additional Accomplishments:

Two fish nutrition projects were completed in cooperation with Dr. Santosh Lall: (1) Lipids in diets of tropical fish (this was basically a training project for visiting scientist Jayantha Chandrasoma) and, (2) lipids and fatty acid composition of several fish meal samples (with Bob Keith); this was part of a more complete assessment of the nutrient composition of several commercially available fish meals, the results are being compiled and will be available from Dr. Lall.

The lobster feed attractant study deferred from last year due to a shut down of the heated seawater system and renovations to the wet lab facilities, was commenced in July and completed in December 1991.

## 5. Goals/Expected Outputs for 1992:

Based upon the approved five-year research proposal (noted in 3), we will begin studies on the nutritional requirements of non-salmonid marine species.

### New Project Description:

In order to support long-term development opportunities in the aquaculture industry the nutritional requirements of marine finfish species other than salmon are studied by; analyzing the nutrient composition of natural, live and formulated feeds; conducting feeding trials using live or formulated diets varying in specific nutrients such as vitamins, lipids, amino acids or mineral elements; and by using radio tracers and short-term physiological experiments in which growth, survival, metabolism, feed conversion and other indices of nutrition are monitored.

### New Long-Term Objectives:

1. Establish the nutritional requirements of marine species which have potential for aquaculture.
2. Analyze the nutrient composition of phytoplankton and zooplankton which might be used to feed larval stages or that could be used in formulated diets.
3. Develop feeds for research and commercial applications.
4. Acquire a basic understanding of the role of essential nutrients (particularly lipids) in the metabolism and physiology of marine organisms.

### Specific Objectives:

1. Scientific Publications:

Completion of outstanding manuscripts on crustacean nutrition research will continue to be a priority. (Castell and Boston)

- a) Effects of feed attractants in diet of lobster;
- b) Design and techniques for crustacean nutrition research;
- c) Standard experimental diets for lobsters;
- d) Vitamin B and Manganese, in lobster molt death syndrome;
- e) molt death syndrome in lobster; and
- f) fatty acid patterns of lobster eggs and larvae.

The work on crustacean nutrition will be phased out during the review year and be replaced with the Non-Salmonid Nutrition Project.

In cooperation with other members of the marine fish culture task force, it is anticipated that a complete bibliography of marine fish culture and nutrition will be prepared and published. (Castell, Waiwood, et.al.)

First draft manuscripts on lipid composition of halibut eggs, larvae and food organisms. (Castell) should also be completed in the next review period and on the possibility of using fatty acid markers in distinguishing geographic origin of lobster larvae. (Boston)

### 2. Laboratory Studies:

This year will principally involve lipid analyses, including analysis of 30 lobster egg samples supplied by Dr. Robert Miller and numerous halibut egg, larvae and food organisms from the marine fish culture project at St. John's, Newfoundland. If time permits, samples of algae cultured in the Halifax laboratory will be analyzed to determine effects of culture conditions on their lipid content and quality.

### 3. Education and Training:

Linda Boston will learn new techniques in lipid analysis by hands-on experience in the laboratory, and possibly by taking a University Course on lipid chemistry. John Castell will gain experience in lipid research techniques during a 10 month developmental leave at the University of Stirling, Scotland, February to December, 1992.

## 6. Background:

### Highlights:

Major effort this year has been spent in developing long-term research plan as agreed upon through discussion with Section Head and Division Chief.

### Selected Involvements:

- i. Collaborative Research -

- ii. University Liaison -

Continuation of cooperative research with Dr. Hans Ackefors, University of Stockholm, Sweden on Astacus astacus nutrition. The current study involves establishing long-term growth and survival pattern for laboratory reared crayfish fed formulated diets.

Lipids of cultured halibut eggs and larvae with Dr. Joe Brown and Dr. Greg Goff at the Memorial University of Newfoundland.

Supervision of Ph.D. students Kim Harrison (degree awarded fall 1991) and Xu Xueliang; and M.Sc. student Danny Jackson (successful defense of M.Sc. January 1992), all in the Biology Department of Dalhousie University.

Gave Aquaculture lecture to International Development Class at the Technical University of Nova Scotia.

iii. Communications -

iv. Contracts Administered -

v. Other -

Expert witness for Revenue Canada and the Department of Justice in research credit case against local lobster wholesale/retail company.

Played a key role in establishing the International Working Group on Crustacean Nutrition as an official working group of the World Aquaculture Society; and coordinating the program for the Crustacean Nutrition Workshop in Singapore October 26-30, 1992.

## 7. Publications:

i. Primary -

Ackefors, H., J.D. Castell, L.D. Boston, P. Ráty, and M. Svensson. 1991. Standard Experimental Diets for Crustacean Nutrition Research. II. Growth and Survival of Juvenile Crayfish Astacus astacus (Linné) fed Diets Containing Various Amounts of Protein, Carbohydrate and Lipid. Aquaculture (in press).

ii. Interpretive Scientific -

Castell, J.D. 1990. Reference diets for Crustaceans: principles of experimentation. In: Barret, J. (Ed.), Advances in Tropical Aquaculture. Advances in Tropical Aquaculture: Workshop held in Tahiti, French Polynesia, Feb. 20-Mar. 4, 1989. Actes Colloq. IFREMER 9: 339-354.

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Baisre, J.A. and J.D. Castell. 1991. Aquaculture in Cuba. World Aquaculture. 22(3):000-000. In Press.

Baum, N., D.E. Conklin, H.D. Castell and L.D. Boston. 1991. Nutritionally Induced Molt Death Syndrome in Aquatic Crustaceans: III. The Effect of Varying Levels of Calcium in the Reference Diet, BML 81S for Juvenile Homarus americanus. The Crustacean Nutrition Newsletter 7(1):115-118.

Castell, J.D., L.D. Boston, D.E. Conklin and N. Baum. 1991. Nutritionally Induced Molt Death Syndrome in Aquatic Crustaceans: II. The Effect of B Vitamin and Manganese Deficiencies in Lobster (Homarus americanus). The Crustacean Nutrition Newsletter 7(1):108-114.

Castell, J.D. and Linda D. Boston. 1991. (Abstract). The effect of feed attractants on feeding behaviour and growth of juvenile lobsters. 14th Fish Health Workshop, Halifax, N.S., November 1991.

Castell, J.D. and K.E. Corpron. 1991. (eds.) Crustacean Nutrition Newsletter. Vol. 7(1). pp. 126.

Conklin, D.E., N. Baum, J.D. Castell, L.D. Boston and Li Hafung. 1991. Nutritionally Induced Molt Death Syndrome in Aquatic Crustaceans: I. Introduction to the Problem. The Crustacean Nutrition Newsletter 7(1):102-107.

## 8. Review and Evaluation:

Over the year the project leader extracted himself from a number of international science tasks, which has allowed him to place greater emphasis on more local concerns. The completion of a long-term research proposal was developed, reviewed and accepted. This proposal will permit his project to concentrate on immediate problems of the Canadian aquaculture industry. Training in Scotland will assist this process. The number of completed manuscripts was disappointingly low.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 243

Section: Aquaculture

Project Title: Fish Nutrition

Project Leader: Lall, S.

Other Researchers: Keith, R.

Work Activity: W.A.1.1.2.3

Key Words: salmon; aquaculture; fish food; nutrition

1. Project Description:

Investigate the nutritional requirements of salmonids and marine fish in relation to growth, development, general health, reproduction, and other physiological functions. Present research is concerned with nutrition of salmonids to provide essential information for government and private culture operations, the feed industry, universities, fisheries management, and assessments.

2. Long-Term Objectives:

Determine the nutrient requirements of salmonids and marine fish for commercial operations; develop analytical and biological techniques to characterize the nutritional deficiencies in cultured and wild fish; provide information on nutritional requirements of salmonids, feed formulations, micronutrient losses in feed, and feed manufacturing techniques to other segments of government, universities, and the private sector; and develop a biological basis for determining salmonid culture potential for economic projections.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Submit the following manuscripts for primary publication:

1. Vitamin B<sub>6</sub> requirement of Atlantic salmon;
2. Vitamin E and immune response;
3. Digestibility of feeds.

Goal partially met.

1. M.S. drafted for internal review for submission to Aquaculture.
2. Internal review complete and ready for submission to Can J. Fish. & Aquat. Sci.;
3. Accepted for publication in J. Sci. Food & Agr.;

2. Continue research on the role of micronutrients in immune response and disease resistance in Atlantic salmon with emphasis on dietary folic acid. (Lall)

It was determined that the folic acid requirement of Atlantic salmon fingerlings can be met by including 4 mg folic acid per kg of diet based on growth, feed utilization, survival and folic acid deposition in tissue. Folic acid deficiency symptoms include: anemia, pale gills, large immature and segmented erythrocytes. Dietary folic acid supplementation has no significant effect on resistance to furunculosis. The analytical work is nearing completion.

3. Start preliminary work to measure the availability of dietary phosphorus in fish feed and to minimize losses of phosphorus to water and sediment. (Lall)

Project on track. The availability of phosphorus to salmon fish feeds and meals ranges from 50-84 %. Although digestibility of menhaden and whitefish meal was significantly better than herring and capelin meal, the total phosphorus excreted by salmon fed menhaden and whitefish meal was relatively high. Various soluble and insoluble phosphorus fractions of feeds and feces were also identified. Results presented at the Int'l Fish Nutrition Symposium, Biarritz, France and Fish Health workshop.

4. Coordinate fish hatchery nutrition programs. Continue to provide advice to private aquaculture operations, feed industry, and universities and maintain a suitable communication link with these agencies. (Lall)

Twenty five commercial feeds were analyzed to determine the quality of feed supplied to federal and private hatcheries and fish farms; several cases of nutritional deficiency were diagnosed; numerous inquiries by from fish culturists, feed industry and aquaculture personnel were answered. Evaluation of silage based feeds for the aquaculture industry was completed and shows silages can be incorporated successfully into salmon feeds. Active participation in aquaculture industry - sponsored courses and seminars continued.

5. Initiate preliminary work to determine the nutritional value of live organisms for halibut

larvae and development of diets for juvenile fish. (Lall) (Degree of involvement subject to the availability of technical support)

Halibut nutrition research program has been transferred to Dr. J. D. Castell.

#### 4. Additional Accomplishments:

1. Conducted preliminary investigation on "Cold water winter lesions in Atlantic salmon" in co-operation with New Brunswick Department of Fisheries and Aquaculture, Connor Brothers Ltd. and Atlantic Veterinary College. The findings were reported in the Can. Vet. Journal.
2. Completed a project in co-operation with the Atlantic Veterinary College and Abbott Laboratories to evaluate several feed attractants and feed supplements to improve the acceptability to Atlantic salmon of feeds incorporating antibiotics. The diet was successful in a pharmacokinetic study of oxytetracycline.

#### 5. Goals/Expected Outputs for 1992:

1. Continue research on the nutrient requirements of Atlantic salmon specifically emphasizing the role of polyunsaturated fatty acids in immune response and disease resistance specifically of salmon to Vibrio anguillarum. (Lall, Keith, Olivier)
2. Develop and test experimental protocols for determining amino acid requirement of Atlantic salmon in sea water, with emphasis on the role of dietary arginine. (Lall, Keith, Kaushik)
3. Co-ordinate fish hatchery nutrition programs. Continue to provide advice to private aquaculture operations, feed industry, and universities and maintain a suitable communication link with these agencies. (Lall)
4. Submit manuscripts on research completed or nearing completion on (a) phosphorus utilization by Atlantic salmon and (b) folic acid requirement of Atlantic salmon. (Lall, Keith)

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

1. Dr. D. Anderson, Truro Agriculture College - Protein quality of fish meals produced in Atlantic Canada.
2. Dr. R. G. Ackman, Technical University of Nova Scotia. - Lipid digestibility; tocopherol and astaxanthin deposition in salmon flesh.
3. Dr. G. Goff, Memorial University & Fisheries Resource Development Ltd. - Halibut nutrition and feeding.
4. Dr. R. L. Saunders, DFO, Biol. Station, St. Andrews, N. B. - Feeding rate and sexual maturation in Atlantic salmon.

##### ii. University Liaison -

1. R. G. Ackman, Technical University of Nova Scotia.
2. Dr. D. Anderson, Truro Agriculture College.
3. Dr. D. Rainie, Dr. G. Johnston and Dr. M. McNiven, Atlantic Veterinary College.
4. Dr. C. B. Cowey, University of Guelph.

##### iii. Communications -

##### iv. Contracts Administered -

##### v. Other -

Progress reported on fish nutrition research at the following scientific meetings and workshops:

1. IV Int'l. Symposium on Nutrition and Feeding of Fish, Biarritz, France.
2. Aquaculture Association of Canada 8th Annual Meeting, St. Andrews, N. B.
3. Fish Health Workshop, Halifax.
4. Aquaculture mini-symposium, Vancouver.

#### 7. Publications:

##### i. Primary -

Polvi, S. M., R. G. Ackman, S. P. Lall and R. L. Saunders. 1991. Stability of lipids and omega-3 fatty acids during frozen storage of Atlantic salmon. *J. Food Sci. Pres.* 15: 167-181.

Takeuchi, T., R.G. Ackman and S.P. Lall. 1991. Differences in fatty acid composition of fish faeces as determined by two extraction methods. *J. Sci. Food Agric.* 56:259-264.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Lall, S. P. 1991. Concepts in the formulation and preparation of a complete fish diet, p. 1-12. In S. S. De Silva (ed.) *Fish nutrition research in Asia. Proc. Fourth Asian Fish Nutr. Workshop. Asian Fish. Soc. Spec. Publ. 5, 205. Asian Fish Soc. Manila, Phillipines.*

Lall, S. P. 1991. Salmonid nutrition and feed production. In R. H. Cook and W. Pennell (eds.) *Proc. Special Session on Salmonid Aquac., World Aquac. Soc. Meet., Feb. 12-16, 1989. Los Angeles, Ca. Can. Tech. Rep. Fish Aquat. Sci. No. 1831: 107-123.*

Lall, S. P. 1990. Nutritional value of fish silage in salmonid diets. *Bull. Aquac. Assoc. Canada.* 91-1:63-74.

O'Halloran, J., E. Saulnier, K. Were, D. Groman and S. Lall. 1991. Cold water winter lesions in Atlantic salmon. *Can. Vet. J.* 32:312.

Ackman, R. G., S. M. Polvi, R. L. Saunders and S. P. Lall. 1990. Human health implications of Atlantic salmon fed different fats. *Bull. Aquac. Assoc. Canada.* 90-4:45-49.

Sigurgisladdottir, S., S. P. Lall., C. Parrish and R. G. Ackman. 1990. Method to determine the digestibility of dietary lipids in Atlantic salmon. *Bull. Aquac. Assoc. Canada.* 90-4:41-44.

iv. Popular and Miscellaneous -

Lall, S. P. 1991. Role of micronutrients in immune response and disease resistance in fish. IV Int'l Symp. Fish Nutrition and Feeding. Biarritz, France, June 24-27, 1991, #3.1 (Abs.)

Lall, S. P. and R. A. Keith. 1991. Biological availability of phosphorus in fish meal for Atlantic salmon. IV Int'l Symp. Fish Nutrition and Feeding. Biarritz, France, June 24-27, 1991, #5.4 (Abs.)

Anderson, J. S., S. P. Lall, D. M. Anderson and M. McNiven. 1991. Lysine requirement of Atlantic salmon. IV Int'l Symp. Fish Nutrition and Feeding. Biarritz, France, June 24-27, 1991, P-8-01 (Abs.)

Lall, S. P. and G. Olivier. 1991. Role of ascorbic acid in Atlantic salmon nutrition. *Aquac. Assoc. Can. 8th Ann. Meet., St. Andrews, N. B., June 10-13, 1991, p.44 (Abs.)*

Anderson, J. S., D. M. Anderson, S. P. Lall and M. McNiven. 1991. Nutritional and chemical characteristics of Canadian fish meal. *Aquac. Assoc. Can. 8th Ann. Meet., St. Andrews, N. B., June 10-13, 1991, p.44 (Abs.)*

Lall, S. P. and R. A. Keith. 1991. Dietary phosphorus in fish: Requirement, Metabolism and Excretion. 14th Regional Fish Health Workshop, November 6 - 8, 1991, #8 (Abs.)

Ackman, R. G., S. Sigurgisladdottir and S. P. Lall. 1990. Effects of tocopherol and astaxanthin on quality of Atlantic salmon, *Salmo salar*. 14th Regional Fish Health Workshop, November 6-8, 1991. p.9 (Abs.)

Anderson, J. S., S. P. Lall, D. M. Anderson and M. McNiven. 1991. Biological availability of amino acids from fish meals for Atlantic salmon, *Salmo salar*. 14th Regional Fish Health Workshop, November 6-8, 1991. p.9(Abs.)

8. Review and Evaluation:

This program continues to produce at 110% capacity. This is reflected in the continued involvement with the aquaculture and aquaculture feed industries as a whole, and the continued demand for advice and assistance. The Research program per se is evolving on schedule and the transfer of responsibility for lipid research to the non-salmonid nutrition program (P242) should allow this group to concentrate on the improvements of diets and feeds for salmonids. The total number of papers and presentations completed in the last year is a significant improvement, but it should be noted that the stress on technical presentations reflects pressure from the industry for promptness in transferring technical information; primaries therefore tend to be tackled less promptly.

The program is making good use of opportunities for collaboration with other scientists and the industry. It's contribution to the field of salmonid nutrition cannot be matched.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 244

Section: Aquaculture

Project Title: Fish Disease Research

Project Leader: Olivier, G.

Other Researchers: Moore, A.; Fildes, J.; Daly, J.

Work Activity: W.A.1.1.2.1

Key Words: fish disease; diagnostics; immunology; aquaculture; salmon; BKD; furunculosis

1. Project Description:

Using in-vitro and in-vivo techniques and the study of wild and cultivated stocks, investigate the bacteriological diseases of fish to determine their epidemiology and etiology, and conduct research leading to the development of eradication techniques and the development of vaccines.

2. Long-Term Objectives:

Develop a full understanding of the common and rare diseases of fish and methods of control to protect both wild and cultivated stocks.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete analysis and publish the comparative efficacy of various diagnostic methods to detect BKD. We will also challenge new fish to confirm our earlier findings that the Margaree stock of Atlantic salmon is more resistant to this disease. (Fildes)

Project partially completed, analysis of the different diagnostic techniques is finished and one paper has been submitted and accepted (see primary publication), a second paper has also been sent for publication. The challenge of additional fish from Margaree and Liscomb stocks is not yet done and is planned for the winter of 91/92.

2. Complete our experimental work on the role of A-layer and LPS in the phagocytosis of A. salmonicida strains by peritoneal macrophages of salmonids using non-cytotoxic strains of A. salmonicida. Prepare manuscript for primary publication. (Moore)

Partially completed. Experimental work is done, but statistical analysis is required before the manuscript can be completed.

3. Determine if antibodies and complement are able to opsonize (i.e. enhance) the phagocytosis of A. salmonicida by peritoneal macrophages of salmonids using non-cytotoxic strains of A. salmonicida. (Olivier)

Project ongoing. The work with complement is complete, but additional assays with new anti-Aeromonas salmonicida sera are required.

4. Determine the Minimal Inhibitory Concentration (MIC) of 60 selected strains of A. salmonicida and correlate the MIC with zones of inhibition obtained by the disk-diffusion method. (Fildes)

Partially completed: the data needs to be analyzed and the manuscript prepared.

5. Investigate the effects of surface components (A-layer and LPS) on the complement system of salmonids using phenotypically characterized strains of A. salmonicida. (Olivier)

Project ongoing, results need to be analyzed before we can determine if additional experiments are required.

6. Determine if strains of the family Vibrionaceae (Vibrio sp., atypical A. salmonicida) are cytotoxic for salmonid macrophages. (Moore)

Project not done due to enhanced workload, see additional accomplishments.

7. Publish manuscript on: Effect of iron on susceptibility of Atlantic salmon to disease. (Olivier)

Insufficient data for manuscript preparation.

#### 4. Additional Accomplishments:

As part of our current epidemiological study of furunculosis using bacteriophage typing, over 100 strains of A. salmonicida were received and the antibiogram and phage typing was carried out on all isolates. Designed an experiment to test the effectiveness of I<sub>1</sub> as a biocide in the labs quarantine facility.

#### 5. Goals/Expected Outputs for 1992:

1. Using brook trout, determine the survival in vivo of cytotoxic and non-cytotoxic strains of the three phenotypes of A. salmonicida. (Fildes, Olivier)
2. Using live vaccines, we will investigate if protection against furunculosis in brook trout is correlated with survival of the vaccine strain in vivo. We will also determine antibody titers in immune fish to verify the role of humoral immunity in protection. (Fildes, Olivier)
3. Investigate the bactericidal activity of brook trout peritoneal macrophages against the various phenotypes of A. salmonicida by adapting the MTT bactericidal assay described by Graham et al. (1988) who were using rainbow trout kidney leukocytes. This assay will be used to investigate the role of cellular immunity in fish vaccinated with live vaccines. (Daly, Moore)
4. Continue and complete our experiments on the role of antibodies and complement on the phagocytosis of A. salmonicida by brook trout and Atlantic salmon peritoneal macrophages. (Moore, Olivier)
5. Investigate the BKD resistance of Atlantic salmon from Margaree. If time and tank space are available, we will repeat the experimental infection of these fish with BKD. (Olivier, Fildes, Daly)
6. Using the MTT assay described earlier, the killing capacity of Peritoneal and Kidney macrophages towards A. salmonicida phenotypes will be compared. (Moore, Daly)

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

Dr. Carol Mackie, University of Glasgow, visited our laboratory for three weeks during which time she was able to induce the production of a gamma-interferon-like activity using our macrophage culture techniques and stimulation of the cells with the mitogen PHA.

##### ii. University Liaison -

##### iii. Communications -

##### iv. Contracts Administered -

Transfer of phage typing techniques to Diagnostic Unit - supervised contractor, D. Williams.

##### v. Other -

#### 7. Publications:

##### i. Primary -

Griffiths, S.G., G. Olivier, J. Fildes and W.H. Lynch. 1991. Comparison of Western blot, direct fluorescent antibody and drop-plate culture methods for the detection of Renibacterium salmoninarum in Atlantic salmon (Salmo salar L.). Aquaculture 97:117-129

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

##### iv. Popular and Miscellaneous -

Bacro, A., G. Olivier and J. O'Halloran. 1991. (Presentation). Preliminary studies on the transmission of bacterial diseases between cultured salmon and wild marine fish. 14th Regional Fish Health Workshop, Halifax, Nova Scotia, November 1991.

Mackie, C., A. R. Moore, G. Olivier and T. H. Birkbeck. 1991. (Poster) The effect of Phytohaemagglutinin on Atlantic salmon (Salmo salar) peritoneal macrophages. 14th Annual AFS/FHS Meeting, Newport, Oregon August 1991, p. 63.

- MacKinnon, A. M., J. Cornick and G. Olivier. 1991. (Presentation). Atypical Aeromonas salmonicida in a wild population of eels (Anguilla rostrata). 14th Regional Fish Health Workshop, Halifax, Nova Scotia, November 1991.
- Moore, A. R. and G. Olivier. 1991. (Presentation). The role of A-layer on phagocytosis of Aeromonas salmonicida. 14th Regional Fish Health Workshop, Halifax, Nova Scotia, November 1991.
- Olivier, G. and A. R. Moore. 1991. (Abstract) The role of A-layer in the phagocytosis of Aeromonas salmonicida cells by salmonid macrophages. The Fifth Congress of the ISDCI (International Society of Developmental and Comparative Immunology), Portland, Oregon, August 1991, F10 p. S73.
- Olivier, G., R. Claveau, J. O'Halloran, J. Fildes, B. Zwicker and J. Cornick. 1991. (Abstract) Multiple antibiotic resistance profiles of Aeromonas salmonicida in two hatcheries experiencing recurrent furunculosis outbreaks. Aquaculture Canada 91, St. Andrews, N.B. June 6-11, 1991.
- Olivier, G. 1991. Survol des principales maladies bactériennes des salmonidés: bactériologie et immunologie. VIe Conférence annuelle en santé animale, Sherbrooke 8-9 mai. 1991 pp. 18-19
- Olivier, G., R. Claveau, J. O'Halloran, J. Fildes, B. Zwicker and J. Cornick. 1991. (Abstract) Multiple antibiotic resistance profiles of Aeromonas salmonicida in two hatcheries experiencing recurrent furunculosis outbreaks. 14th Annual AFS/FHS Meeting, Newport, Oregon August 1991. Abstract p. 36.
- Olivier, G. Research on bacteriology and immunology of fish at the Halifax Laboratory: a review. Dalhousie Seminar Series, Dalhousie University, October 17th, 1991.

#### 8. Review and Evaluation:

This investigation continues to perform at the cutting edge of fish disease and immunology research, and provide a needed consultation service to the Diagnostic Unit. The demand for information on diseases considerably exceeds the Research Unit's capacity to respond, and the addition of PDF, Dr. J. Daly enhances their capability, but at significant financial cost to the Unit, Section and Division. The Independent Review of Disease Research, conducted one year ago, clearly supported this program and suggested other areas where research was urgently required. Nevertheless, the A-base budget was not enhanced. The Division extended its O&M budget by funding a PDF and can do no more. Disease is an important but neglected discipline in DFO's overall research program. More attention is urgently required to permit the expected growth in aquaculture and to resolve problems with wild stocks.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 245

Section: Aquaculture

Project Title: Parasitology

Project Leader: Morrison, C.

Other Researchers: Marryatt, V., Leger, J. (summer student)

Work Activity: W.A.1.1.2.1

Key Words: fish disease; diagnostics; parasitology; aquaculture

1. Project Description:

Histology, histopathology and parasitology of finfish and shellfish.

2. Long-Term Objectives:

Develop a series of histological atlases of cod; provide support to the diagnostic group; and conduct taxonomic studies of protozoan parasites in marine fish.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete and publish Cod Atlas, Part 4 - Larval Development. (Morrison)

Goal not met. Completion delayed because the larval studies more complex than anticipated, and the histology technician, V. Marryatt, retired. (Morrison, Marryatt, Leger)

2. Start Cod Atlas, Part 5 - Supportive Tissues (cartilage, bone, notochord, and muscle), and skin and scales. (Morrison)

Goal not met. See above and enhanced workload. (Morrison)

3. Process and examine cases from diagnostic unit as required. (Morrison)

Two cases from diagnostic unit and two of fish parasites from Dr. Gary McClelland were processed for histology. (Morrison, Marryatt, Leger)

4. Complete work on Goussia gadi in cod and haddock. (Morrison)

Goal not met. See 3.1 and enhanced workload. (Morrison)

4. Additional Accomplishments:

1. By researching the literature, companies, potential S.E.M. (scanning electron microscope) users in this laboratory and S.E.M. users in other laboratories, ordered the most suitable S.E.M. for Halifax Laboratory. (Morrison)

2. E.M. suite for T.E.M. (transmission electron microscope) and S.E.M. at Halifax Laboratory planned in conjunction with DPW, Facilities Management personnel and the Hitachi Company. Construction begun. (Morrison)

5. Goals/Expected Outputs for 1992:

1. Start Cod Atlas, Part 5 - Supportive Tissues (Cartilage, bone, notochord, and muscle), and skin and scales. (Morrison)

2. Complete work on Goussia gadi in cod and haddock. (Morrison)

3. Process cases from Diagnostic Unit and Dr. McClelland as required. (Morrison)

4. Start survey and study of ultrastructure of prokaryote organisms in bivalves. (McGladdery and Morrison)

5. Start study of life-cycle of Pleistophora hippoglossoides in American plaice. (McClelland and Morrison)

6. Start collaborative SEM study with Mark Powell, Research associate at AVC, on defense mechanisms of trout gill. (Powell, Burka, Morrison)

6. Background:

## Highlights:

## Selected Involvements:

- i. Collaborative Research -  
J. Neilson, Marine Fish Division, St. Andrews, N.B.
- ii. University Liaison -  
Member of committee for graduate student, Patrick Wells at Dalhousie University.
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -  
Morrison, C.M. 1991. Further observations on the sporogony of Eimeria sardinae in the testis of the herring, Clupea harengus L. Canadian Journal of Zoology. 69: 1017-1024.
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -  
Morrison, C. 1991. The digestive tract of the cod eleutheroembryo ("yolk-sac larva") and larva. SCR Doc. 91/105, Serial No. N1997  
Morrison, C. 1991. The reproductive stages of cod. Gross and anatomy and histology. SCR Doc. 91/106, Serial No. N1998.  
Morrison, C. 1991. (Abstract) The ultrastructure of the microsporidian parasite Pleistophora hippoglossodeos in the American Plaice Hippoglossoides platessa. Fish Health Workshop, Halifax, Nova Scotia, November 1991.

8. Review and Evaluation:

The project has been reasonably successful, notwithstanding the delays to the production of the Cod Atlas, caused in part by its length, and in part by lack of technical assistance. Production and publication of the atlas itself will be a considerable drain on the Section's monetary resources, so the delay is not entirely unwelcome. Much attention has been given to the selection of a new Scanning Electron Microscope, and the design of a laboratory suite to house it and the older Transmission EM. The suite, when finished, will provide a valuable resource for other workers as well as for the histology program. The planned inclusion of new work on bivalves is a welcome augmentation to the scope of the program.

This is the only project with histological expertise in DFO in the Atlantic Zone and thus must be nurtured with sufficient funds to make good use of the skills and equipment available.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 246

Section: Aquaculture

Project Title: Molluscan Culture and Phytotoxin Research

Project Leader: Scarratt, D.

Other Researchers: Freeman, K.; Kean-Howie, J. (see P247); Bradford, B.

Work Activity: W.A.1.1.1.7; W.A.1.1.2.2

Key Words: domoic acid; aquaculture; mussels; oysters; scallops; phytotoxins;  
nutrition; molluscan culture1. Project Description:

Research into the physiology and ecology of invertebrates in support of the development of the aquaculture industry in the Scotia-Fundy Region. In collaboration with Inspection Branch, Habitat Ecology Division, and Physical and Chemical Oceanography, determine rates of uptake and depuration of marine toxins by commercial molluscs.

2. Long-Term Objectives:

Apply scientific knowledge and information to the development of an economically viable invertebrate culture industry in Scotia-Fundy. Describe the dynamics of toxin uptake and depuration by molluscs and develop protocols for depuration.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Technical report published on work carried out under contract with M. McInerney-Northcott. (Scarratt)

Goal not met. A bibliography and an incomplete outline of the discussion of this MS was received from the contractor in November 1990. Since then nothing further has been received and the matter has been referred back to DSS for failure of the contractor to complete the contractual obligations. DSS will attempt to persuade the contractor to complete the contract, or, if she remains non-cooperative, to recover all notes, written material, photocopies, samples, and drafts of reports relevant to the study. The hold-back would be forfeited. DSS may attempt to recover some of the principle.

2. Publish in the primary literature, work on domoic acid protocol development.

Goal not met (see Goal 11).

Goal not met. Collaborative paper (Scarratt, Freeman) with Gulf Region staff (Smith, Angus) awaits section on experimental Domoic acid budgets and chlorophyll measurements.

3. Publish two manuscripts on bay scallop studies.

Goal not met (see Goal 12). Preliminary results presented at Fish Health Workshop.

Goal not met. Data on growth of two year classes of bay scallops under laboratory conditions and at different sites around Nova Scotia are assembled and ready for analysis.

4. Complete construction of wet-laboratory facilities for molluscan culture and depuration research. Refurbish existing dry-labs. (Scarratt)

Goal not met. Wet-lab fully completed and operational with the exception of assembly of second ultra violet sterilisation unit, which is under construction. Dry labs re-allocated but not refurbished due to lack of funds.

5. Examine breeding of F1 generation of M. edulis/trossulus crosses, including seasonality of spawning of adults. (Freeman)

Goal not met. Animals held and fed in the laboratory failed to reach sexual maturity. Intense field sampling of both species for both condition and gametogenic indices conducted from spring to late fall; results partially analyzed. (with K. Perry, B.Sc. Honours student)

6. Publish manuscript on fecundity of M. edulis and the relationship of egg size to larval survival. (Freeman)

Goal not met. Some of the eggs used in this study are now believed to be from M. trossulus. A reassessment of data will be required before this manuscript can be completed.

7. Publish manuscript on distribution of M. edulis/trossulus in a single lease. (Freeman)

Goal not met. Manuscript extended to incorporate data from larval rearing experiments and is in internal review stage.

8. Preparation of manuscript on juvenile feeding, larval feeding, and proximate analysis of scallops. (Kean-Howie)

Transferred to P 247

9. Continue determination of optimal conditions for presentation of microparticulate diets to bivalve larvae and juveniles, in collaboration with R.K. O'Dor and D.J. Wildish. (see collaborative programs). (Kean-Howie)

Transferred to P 247

10. Measure digestibility of microparticulate diets in collaboration with Dr. C. Langdon, Oregon State U. (Kean Howie)

Transferred to P 247

11. Complete pilot scale experiments on the elimination of domoic acid from mussels and bay scallops and the preparation of protocols. (Scarratt)

Goal not met. Pilot scale depuration requires there to be a significant domoic acid outbreak since production of Nitzschia in ultra large volumes is not possible in laboratory conditions. One small scale run with mussels has been possible during a brief Nitzschia bloom at New London, PEI, but not with bay scallops since the bloom was too short. Outerbridge has submitted text of M.Sc. thesis from which a progress report can be prepared. (Outerbridge and Scarratt)

12. Attempt to develop protocols for breeding Perkinsus-free larvae of Argopecten irradians. (Scarratt)

Goal not met. Bay scallop eggs and infective parasite stages appear to be released synchronously. Surface disinfection may cause high larval mortality. Surviving scallops will be examined when fully mature.

13. Editing and publishing of two reports written under contract by C. Enright. (Scarratt)

Goal met. Both Manuscripts (Scallops, and European Oysters) are now in final draft and choice of figures is being finalised. Estimated completion date: late January.

14. Breed F2 generation of introduced bay scallops, Argopecten irradians, and introduce new scallops into quarantine from the U.S. to establish 3rd genetic line. Continue performance trials of existing strains. (Scarratt)

Project continued. F2 generation has been retrieved from the field (October 1991) and will be conditioned for spawning in early spring. (See also 3,2. above) Attempts to bring in a second breeding stock were deferred due to lack of time. (Bradford and Scarratt)

#### 4. Additional Accomplishments:

1. Collaboration with Working Group on Introductions and Transfers of Fish and Shellfish to Prince Edward Island. Matrix developed to identify species, purpose of transfer, source of stock and appropriate control measures to minimize, disease, genetic, ecological and environmental threats. (Scarratt)
2. National Working Group on Development of Manual of Compliance for Shellfish Health Protection Regulations; Identifications of vulnerable species, diseases of concern, diagnostic protocols for lobsters, shrimps and crabs; first draft completed. (Scarratt)
3. Completed preparation of Sector Development plans for Mussels; Bay scallops; Alternate Species, for N.S. Aquaculture Co-ordinating committee. Assisted with drafting plan for European Oyster (with C. Enright)

#### 5. Goals/Expected Outputs for 1992:

1. Complete and publish manuscript on Mytilus edulis and trossulus morphs. (Freeman et al)
2. Reevaluate and publish data on fecundity, egg size and larval viability of Mussels. (Freeman)
3. Evaluate fertility of M. edulis x trossulus hybrids, including gametogenic index and publish results. (Freeman, Perry)
4. Evaluate settling times of larvae of M. edulis and M. trossulus on a commercial lease where both species exist. (Freeman, Bradford) (Requires contract with S. Hancock for Mpi analysis)
5. Test protocols for depuration of domoic acid from naturally and artificially contaminated mussels, bay scallops and american oysters. (Scarratt)
6. Breed F3 generation of introduced bay scallops, Argopecten irradians, and continue performance trials of existing strains. (Scarratt, Bradford) Continue attempts to develop a Perkinsus-free strain.

#### 6. Background:

Highlights:

Positive Highlights include the completion of the larval rearing and molluscan nutrition wet laboratories.

Negative Highlights (lowlights) centred on the overall failure of larvae to survive in laboratory conditions. This appears to have been a common problem in all East Coast hatcheries in 1991 and may be related to general water conditions rather than being a specific feature of this laboratory.

The failure of expected AFAP funding to be awarded to related integrated projects has set the edulis/trossulus study back a year.

#### Selected Involvements:

##### i. Collaborative Research -

Isoenzyme characterization of Maritime Mussel stocks, (AFAP proposal with Mallet Research Services). This study is partially complete and awaiting continuance of AFAP funding for completion.

##### ii. University Liaison -

Freeman with Drs. Zouros, Pogson and Ball, Dalhousie University. Assessment of mitochondrial DNA in within and between matings of Mytilus edulis and M. trossulus; first round of analyses on genome heritability is almost complete.

Freeman, committee member and supervisor for Katharine Perry, Honours student, Mt. Allison University, Sackville N.B. on spawning of mussel species, viability and growth of crosses, seasonality of maturity and spawning. For completion 1992.

Scarratt, committee member and supervisor for Renata Outerbridge, Masters student at Dalhousie University, uptake and elimination of domoic acid. For completion December 1991.

##### iii. Communications -

The Occurrence of Mytilus edulis and M. trossulus in the Canadian Maritime Provinces and the Implications for the Mussel Culture Industry, by K. Freeman, A. Mallet, C. Carver, S. Hancock and D. Scarratt. Presented by D. Scarratt at European Aquaculture Conference, Dublin. June 1991.

Aquatic Toxicology - The Wider Implications of Eastern Canadian Shellfish Toxins, by D.J. Scarratt. Presented at the Aquatic Toxicology Workshop, Ottawa, October, 1991.

A laser diffraction technique for measuring shell growth of Blue Mussels: A potential bioassay application, by K. Freeman and H. Sushko. Presented by K. Freeman at the Aquaculture Workshop, Dalhousie University, July 1991.

Reproductive aspects of Mytilus edulis and M. trossulus from a Nova Scotia mussel farm, by K. Freeman, K. Perry and B. Bradford. Presented by K. Perry at the 14th Regional Fish Health Workshop, Halifax, November, 1991.

Dynamics of Perkinsus karlssoni, (Apicomplexa) in Bay Scallops (Argopecten irradians) imported from Cape Cod, Mass. and held in quarantine, by S. MacGladdery, B. Bradford, R. Outerbridge and D.J. Scarratt. Presented by B. Bradford at 14th Regional Fish Health Workshop, Halifax, November, 1991.

##### iv. Contracts Administered -

With South West Nova Aquaculture Association: Production of Proceedings of Workshop on Integrating Aquaculture with Traditional Fisheries. (Bradford and Scarratt) AFAP funding.

With Mallet Research Services: Identification of M. edulis and M. trossulus populations in Atlantic Canada. (Freeman and Scarratt) AFAP funding.

With Corlan Research (Dr. G. Jones): Pathology of Mussels and Bay Scallops exposed to domoic acid. Two manuscripts complete, diagrams and figures nearing completion, estimated completion date for manuscript: Dec 1991. (Scarratt)

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Sushko, H and K. R. Freeman. 1991. The Use of laser diffraction in measuring the effect of suspended sediment on the shell growth of mussels Mytilus edulis. Can.

Manuscr. Rep. Fish. Aquat. Sci. No. 2121: 28 p.

iv. Popular and Miscellaneous -

"...from the lab" by D.J. Scarratt. Newspaper column on aquaculture related matters published monthly in Atlantic Fish Farmer:

January	The need for Shellfish Health Protection Regulations.
February	The Value of Aquaculture Training Courses.
March	Vaccination Experiment runs into Medicated Feeding Snag.
April	Communications in Aquaculture
May	Retirements, and the Newfoundland Aquaculture Workshop
June	The 1991 European Aquaculture Conference, Dublin
July	Shellfish Culture in Ireland
August	Further outbreaks of DSP in Nova Scotia
	and Aquaculture and the Environment
September	Oyster Culture in Australia
October	Announcing the Fish Health Workshop
November	Review of the 1991 Regional Fish Health Workshop

8. Review and Evaluation:

This project has a large number of incomplete tasks, which does not bode well, given a possible major personnel change in the offing. It is most important that this project take seriously its scientific writing commitments. A plan will be put in place to relieve the project leader of certain responsibilities, to permit the placing of emphasis on scientific writing. Considerable effort has been expended on ancillary tasks such as working group introduction, manuals of compliance, sector development plans, etc. Time spent on these have prevented the completion of goal set under the projects long term objectives.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 247

Section: Aquaculture

Project Title: Molluscan Nutrition

Project Leader: Kean-Howie, J.

Other Researchers: Bradford, B.

Work Activity: W.A.1.1.2.2

Key Words: bivalve; shellfish; microparticle; synthetic diets; nutrition; ecophysiology

1. Project Description:

Investigate the nutritional requirements of bivalve molluscs in relation to their ecophysiology and life history with a view to development of a successful nutrition protocol for bivalve hatcheries.

2. Long-Term Objectives:

Plan and implement a molluscan nutrition research program; determine specific nutrient requirements of bivalve molluscs; monitor and evaluate the information needs of shellfish producers with respect to nutrition physiology; develop and test new research tools, especially synthetic diets and measure indices of response to these tools; determine suitable protocol for experiments with synthetic diets; evaluate existing and develop new analytical techniques for biochemical analyses.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Preparation of manuscript on juvenile feeding, larval feeding, and proximate analysis of scallops.

Project incomplete. Data acquisition complete, analysis and MS started.

2. Continue determination of optimal conditions for presentation of microparticulate diets to bivalve larvae and juveniles, in collaboration with R.K. O'Dor and M.A. Silva (see collaborative programs).

A molluscan nutrition wet lab facility has been constructed to a design based on information acquired during experiments conducted at Dalhousie and Oregon State Universities. Two feeding experiments have been completed with giant scallop (Placopecten magellanicus) larvae and data reduction is in progress.

3. Measure digestibility of microparticulate diets in collaboration with Dr. C. Langdon., Oregon State U.

Preliminary results indicate procion dyes can be used successfully in determining digestibility of synthetic diets by bivalve larvae.

4. Additional Accomplishments:

1. Completed measurements on larvae of Manilla clams and Pacific oysters from experiments conducted in Oregon. Presented seminar on these data to Halifax lab personnel.
2. Collected field samples for proximate analysis of juvenile sea scallops (with M. Dadswell).
3. Completed course in Priority Management.

5. Goals/Expected Outputs for 1992:

1. Completion and successful defence of dissertation by March 31. (Kean-Howie)
2. Complete the preparation of manuscripts based on PhD thesis. (Kean-Howie)
  - a) Feeding trials with juvenile bay scallops and sea scallops using microparticulate diets.
  - b) Changes in proximate composition of juvenile sea scallops over their first two years.
3. Review and evaluate the requirements of bivalve culture operation with respect to nutrition management and practises. (Kean-Howie)
4. Plan and conduct experiments on food presentation protocol for larval studies, specifically the use of shakers to retain diets in suspension. (Kean-Howie)

## 6. Background:

### Highlights:

Rigorous examination of the nutrient requirements of bivalve molluscs can be accomplished only through the use of microparticulate diets. The Biocogent bivalve diet has been accepted and digested by larvae of manilla clams and Pacific oysters. Construction of a wet lab facility suitably equipped for controlled nutrition experiments has permitted successful experimentation with scallop larvae at the Halifax lab.

### Selected Involvements:

#### i. Collaborative Research -

1. Dr. R.K. O'Dor and A. Silva, Dalhousie University; larval feeding studies.
2. Dr. C. Langdon, Oregon State; procion dye.
3. Dr. M Goldstein, Biocogent, Long Island; production of microparticulate diets.
4. Dr. R.G. Ackman, TUNS; lipid analysis.
5. Dr. M. Dadswell, Acadia University; field program.

#### ii. University Liaison -

#### iii. Communications -

Attended and assisted with registration for meeting sponsored by APICS Aquaculture Committee;

Organized meeting for Canadian delegates attending the National Shellfisheries Association annual meeting (denied permission to attend);

Chaired session on Bivalve Culture during annual Fish Health Workshop.

#### iv. Contracts Administered -

Nancy Irwin; with project leader: successful completion of hundreds of biochemical analysis of field and laboratory specimens.

#### v. Other -

## 7. Publications:

### i. Primary -

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

Kean-Howie, J.C.; D.J. Scarratt, R.K. O'Dor. (in press) The Evolution of Feeding Strategies Throughout the Life History of Bivalves with Emphasis on Ontogeny and Phylogeny. ICES Publication. Rapport et Proces-Verbaux.

### iv. Popular and Miscellaneous -

Harrison K.E. and J.C. Kean Howie. 1991. Study Guide on Crustacean Reproduction for Aquaculture Graduate Program, Deakin University; Australia.

## 8. Review and Evaluation:

The completion of the major task within this project is now one year past the date set by the project leader. Poor health, technical limitations within the building, and limited access to technical assistance have adversely impacted the study. It is most important that the study be brought to fruition as soon as possible (the project leader has set March 31, 1992 as completion date). We look forward to the project beginning a new thrust following a carefully planned, long term research proposal which will take advantage of the new wet lab facility now in place.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Benthic Fisheries and Aquaculture

Project No.: 248

Section: Aquaculture

Project Title: Fish Health Services Unit

Project Leader: Cornick, J.

Other Researchers: Zwicker, B. (to June 91); McMenemy, M.; MacKinnon, A-M. (contract to Aug 91, then indeterminate September 91); Williams, D. (contract)

Work Activity: W.A.1.1.2.1

Key Words: diagnostics; fish health; fish disease; furunculosis; BKD; aquaculture; salmon

1. Project Description:

This project 1) provides diagnostic service, formulates and administers quarantines, and regulates movements of salmonids and their products under FHPR; 2) provides diagnostics and implements Regional Fish Health Guidelines for intra-provincial salmonid movements; 3) is responsible for fish health matters related to federal fish culture systems; 4) investigates disease aspects of fish kills in the wild; 5) provides diagnostic and counselling service to government agencies and the aquaculture industry with respect to both finfish and shellfish; 6) assists in the transfer of technology in fish disease diagnosis by providing informal training as well as workshops and seminars with the industry; and 7) develops, in cooperation with industry, disease control programs to eliminate specific health problems.

2. Long-Term Objectives:

To: 1) prevent introduction of foreign disease agents into the Maritime provinces; 2) control the spread of the diseases such as Furunculosis, ERM and BKD between watersheds within provinces; 3) prevent or minimize the impact of disease on hatchery-reared fish and provide counselling service; 4) pinpoint the effects of disease agents in fish kills in the wild; 5) minimize the effects of disease and provide counselling on fish health matters to the aquaculture industry; 6) strengthen private sector disease control capability through technology transfer; 7) reduce economic losses related to specific health problems; and 8) study the distribution of fish diseases throughout the Maritime provinces.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Administer FHPR, in Nova Scotia and New Brunswick in order to prevent introduction and transfer of disease agents into and between provinces. Provide advice on changes to the FHPR including Manual of Compliance. (Cornick)

Project completed satisfactorily. 32 Import Permits (authority as Local Fish Health Officer) issued and 61 inspections (authority as Fish Health Official) completed. M.I. Campbell (Gulf Region) collected samples and assisted in lab for Gulf Region cases. No foreign disease agents detected despite considerable movement of salmonid fish and eggs into and between provinces. Input to revision in the FHPR initially to the Technical Committee and again during discussion on revision at the Local Fish Health Officers Meeting in Halifax. Agreement in principle on adoption of zoning concept for administration of FHPR. Involvement in design of standardized FHPR Import Permit.

2. Administer Regional Fish Health Policy to control intra-provincial movement of furunculosis ERM and BKD and continue the revision of existing guidelines toward making the Policy a Regulation. (Cornick)

Successful completion of diagnostics in support of 155 intraprovincial, interwatershed transfers under this program with no disease outbreaks recorded. Existing guidelines under review for promulgation as a regulation in 1992.

3. As appointed U.S. Title 50 certifying Official, provide certification for fish transfers into the U.S. (Cornick)

A total of 56 U.S. Title 50 permits were issued to Maritime salmon and trout growers.

4. Provide diagnostic and counselling service to federal hatcheries in the Scotia-Fundy Region. (Cornick, MacKinnon, McMenemy)

No major disease outbreaks were recorded. No furunculosis was detected at Mactaquac FCS during the monitor program this year. Swim bladder fungal infection appeared periodically at low prevalence and with low loss. Stocks from all hatcheries were examined and passed under the Regional Fish health Policy for stocking intraprovincially.

5. Investigate disease as a cause of wild fish kills. (Cornick, MacKinnon, McMenemy)

22 lots of various species examined in 1991 and reports filed. No significant infectious disease associated with any kill.

6. Provide diagnostic and counselling service to other government agencies and private aquaculturists, as resources permit. Encourage and strengthen private sector capability to detect and control disease by providing advice and counsel and referring appropriate cases to private diagnosticians. (Cornick, MacKinnon, McMenemy)

Demand for services at same level as last year. Although specific demand for FHPR certification increased (mostly FHPR III [meat fish]) this is expected to be reduced in the coming year for FHPR III inspections dropped. All cases accepted were effectively handled. Typical furunculosis was diagnosed in Atlantic salmon at 3 marine cage sites in Bay of Fundy in New Brunswick. Mortality was low and effectively controlled by drugs. Atypical furunculosis was identified in association with skin lesions and mortality in a population of wild eels in Bras D'or Lake. Work continuing on this problem. Bacterial kidney disease, identified in 3 marine cage sites and 3 freshwater hatcheries in N.B., was effectively controlled. Attempts to withdraw services covered by private sector diagnosticians continues. More control over cases accepted was exercised, resulting in more referrals. Diagnostic information exchange is still a problem, but this will improve with the adoption of revised FHPR.

7. Conduct surveys on private fish culture facilities and wild populations, in order to establish a disease profile for the Maritime Provinces. (Cornick, MacKinnon, McMenemy)

Incomplete. Had anticipated initiating this as FHPR III schedule inspection demands decreased. However, this did not materialise so survey work was not done.

8. Cooperate with N.B. Department of Fisheries in the control of vertical transmission of BKD in N.B., by advising on the conduct of the brood stock screening program. Continue the Carrier testing program for Furunculosis for both private and Government sector facilities. (Cornick MacKinnon, McMenemy)

We had more consultation with N.B. Dept of Fisheries and Aquaculture this year re broodstock BKD monitoring program, in an attempt to reduce spread of BKD. In spite of this, BKD was again a particular problem last year with outbreaks occurring at one major smolt producer and 3 marine cage sites. The situation is now under review with NBFA. We participated, with good results, in meetings of the N.B. Disease Advisory Control Committee to address the immediate problem. With Dr. Olivier assisted Sea Farm Canada Inc. in evaluation of their BKD broodstock monitor programme.

9. Develop protocols for examination of shellfish to minimize transfer of disease in native and introduced species. (Cornick, MacKinnon, McMenemy)

In collaboration with S. McGladdery of Gulf Region, examined 13 lots of shellfish to determine disease status. As part of a National Exercise, contributed to an ongoing review of shellfish diseases and diagnostics to determine basis for new regulations.

10. Provide Diagnostic services as required for DFO, Gulf Region. (Cornick, MacKinnon, McMenemy)

Under a memorandum of understanding, 154 cases were referred to PHDU and satisfactorily completed. An annual report of work conducted in 1990-91 submitted. Work load increased by 10%.

11. Provide other services as required. (Cornick, MacKinnon, McMenemy)

Other services have included certification (FHPR II) of one facility for Newfoundland Region and diagnostics (with Dr. Olivier) for one culture facility in Québec Region experiencing severe furunculosis.

In addition, contributed to review of 12 proposals for introduction transfers of various finfish and shellfish stock under the Introduction and Transfer Committee.

#### 4. Additional Accomplishments:

1. Two experimental transfers, under Section 4, permits for salmon parr movements from Québec and N.B. into N.S., were organized, evaluated, and associated diagnostics completed.
2. Two other experimental transfers of salmon smolts from N.B. to N.S. were organized, isolation facilities inspected and broodstock monitored.
3. Contributed to review of 12 proposals for introduction and/or transfer of various finfish and shellfish stocks under authority of S-F Region Introduction and Transfers Committee.
4. Provided, on job diagnostic training for one veterinary medical student for course requirement.
5. Phage typing technology successfully transferred from research to routine diagnostic use by Fish Health Unit. (D. Williams under contract)

#### 5. Goals/Expected Outputs for 1992:

1. Administer FHPR, in N.S. and N.B. in order to prevent introduction and transfer of disease agents into and between provinces. Provide advice on revisions to the FHPR including Manual of Compliance. (Cornick)
2. Administer Regional Fish Health Policy to control intra-provincial movement of furunculosis, ERM and BKD and continue the revision of existing guidelines toward making the Policy a Regulation. (Cornick)

3. As appointed U.S. Title 50 Certifying Official, provide permits for fish transfers into the U.S.A. (Cornick)
4. Review proposals and make recommendations based on disease considerations for finfish/shellfish introductions and/or transfers under authority of Introduction and Transfer Committee and supervise associated quarantines. (Cornick)
5. Provide diagnostic and counselling service to federal hatcheries in the S-F Region. (Cornick, MacKinnon, McMenemy)
6. Investigate disease as a cause of wild fish kills. (Cornick, MacKinnon, McMenemy)
7. Provide diagnostic and counselling service to other government agencies and private aquaculturists, as resources permit. Encourage and strengthen private sector capability to detect and control disease by providing advice and counsel and referring appropriate cases to private diagnosticians. (Cornick, MacKinnon, McMenemy)
8. Conduct surveys on private fish culture facilities and in the wild, in order to establish a disease profile for the Maritime Provinces. Reallocate resources formerly assigned to FHPR III certifications to this function. (Cornick, MacKinnon, McMenemy)
9. Cooperate with N.B. Department of Fisheries and Aquaculture and N.S. Dept. of Fisheries in the control of vertical transmission of BKD in N.B., by advising on the conduct of the brood stock screening programs. Continue the Carrier testing program for Furunculosis for both private and government sector facilities in N.B., but gradually phase out involvement as NBFA capability comes on line. (Cornick, MacKinnon, McMenemy)
10. Develop protocols for examination of shellfish to minimize transfer of disease in native and introduced species. (Cornick, MacKinnon, McMenemy)
11. Provide Diagnostic services as required for DFO, Gulf Region. (Cornick, MacKinnon, McMenemy)
12. Provide other services as required. (Cornick, MacKinnon, McMenemy)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

N.B. Fisheries and Aquaculture staff - BKD and furunculosis control programs in N.B. (Cornick, Zwicker, MacKinnon)

N.B. Fisheries and Aquaculture staff - Investigation of vibriosis outbreaks in Bay of Fundy. (Zwicker/MacKinnon)

Dr. Olivier (BFAD Project 244). Characterization of Aeromonas salmonicida isolates to strain by phage typing; transfer to routine use in FHU completed (Cornick, Zwicker, Williams) and investigation of atypical furunculosis in wild eel population in Bras D'Or Lakes, N.S. (MacKinnon and Cornick).

Gulf Region: Provision of diagnostic services and collaboration on shellfish health inspections with Gulf Region Staff (Cornick, Zwicker, MacKinnon, McMenemy).

##### ii. University Liaison -

##### iii. Communications -

Fish Health Disease Diagnosis and Control (Cornick, Zwicker) lecture to N.S. Community College Course on The Business of Aquatic Farming, Shelburne, N.S., Jan. 1991.

##### iv. Contracts Administered -

Sea Farm Canada Joint Venture Agreement - Disease diagnostics including BKD broodstock monitor. (Williams, July-Dec/91)

##### v. Other -

Co-chair (Cornick) with G. Olivier. Technical Session on Diseases Aquaculture Assoc. of Canada 8th Annual Meeting, St. Andrews, N.B., June 1991.

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

Cornick, J.W. and G. Olivier. 1991. Fish Health in Aquaculture in Science Review 1988 and 1989, pp. 44-47, 1991.

Cornick, J.W., A.M. MacKinnon, and M.M. McMenemy. 1991. (Abstract). Current Status of Important Diseases Affecting Finfish Culture in the Maritime Provinces. DFO Scotia-Fundy Region 14th Regional Fish Health Workshop, November 1991.

MacKinnon, A.M., J.W. Cornick, and G. Olivier. 1991. (Abstract). Atypical Aeromonas salmonicida in a wild American eel Anquilla rostrata population. DFO Scotia-Fundy Region 14th Regional Fish Health Workshop, November 1991.

Cornick, J.W. .1991. (Abstract). DFO programs aimed at preventing disease transfer through broodstock. Atlantic Salmon Federation, Workshop on Broodstock Development, St. Andrews, N.B., Feb. 27, 1991.

8. Review and Evaluation:

The Fish Health Unit continues to provide a first-class diagnostic program, and a service to clients that has become the ne plus ultra, in Atlantic Canada. The transfer of duties from outgoing to incoming laboratory supervisor was accomplished without loss of efficiency or accuracy.

The value of the program is reflected by the offer from Sea Farm Canada, to fund a contractor to work under FHU direction on certain Sea Farm requests, with surplus time available for routine work. Without this financial and human input, and labour provided by students and trainees, the core program could not be completed, nor could some of the work be done due to lack of critical mass in the laboratory. The program is thus under-funded and understaffed. Its success is due largely to the dedication, skill and loyalty of the staff.

**FRESHWATER AND ANADROMOUS DIVISION**

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 300

Section: Administration

Project Title: Division Administration

Project Leader: Ritter, J.

Other Researchers:

Work Activity: W.A.1.1.1

Key Words: research direction, Division administration

1. Project Description:

This program manages the overall scientific and administrative operation of the Division by providing: (a) professional level advice and direction to Section needs; (b) administrative support to all staff; and (c) executive level contact with clients, the general public, and other government divisions and branches (federal, provincial, international).

2. Long-Term Objectives:

The continuing objective of this project is to direct the activities of the FW&A Division to effectively meet the requirements of the Division's mandate.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Ensure that the Division's mandate and the requests from the Science Directorate in FY 1991/92 are carried out and met in the most effective manner. (Ritter)

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 301

Section: Stock Assessment and Enhancement

Project Title: Salmon Assessment Research

Project Leader: Marshall, T.

Other Researchers: Amiro, P.; Cutting, R.; Jessop, B.; O'Neil, S.; Ritter, J.

Work Activity: W.A.1.1.1.1

Key Words: salmon; assessments; assessment research

1. Project Description:

Enumeration and monitoring of adult and juvenile stocks and Atlantic salmon harvest, preparation of required stock assessment documents, research into methodologies for improvement and expansion of salmon stock assessments, and provision of regional input to Canadian input on international matters involving Atlantic salmon.

2. Long-Term Objectives:

The Departmental legislated mandate includes the responsibility for managing anadromous fish resources according to current, sound scientific information. The long-term objectives of the project are to develop required data bases, conduct pertinent studies and analyses, and prepare biological advice and recommendations on a timely basis for internal and external clients having interests in the valuable Atlantic salmon resources.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare required assessments of Atlantic salmon stocks to define stock status, such as Saint John, St. Croix, LaHave, Stewiacke, Liscomb, St. Mary's, Grand and Middle and inner Fundy rivers and, where possible, forecast future returns. (Marshall, Amiro, Cutting, Jessop)

Stock assessment for the upper Saint John River was vetted at ACFE Subcommittee, CAFSAC, and will be upgraded to Research Document. Also vetted were conservation levels and preliminary estimates of future surpluses for the Grand, Baddeck, Middle, North (Victoria Co), St. Mary's, Liscomb, East and West rivers Sheet Harbour, Musquodoboit, Gold, LaHave, Medway, Mersey, Tusket, Shubenacadie, Stewiacke, Big Salmon and Nashwaak rivers. Background material to the above advice contributed to an assessment of regional stock status by Salmon Fishing Area (below). Retirement and non-replacement of the last two technicians involved with conductance of field surveys and ageing of salmon (over 65 years combined experience) on the Saint John River reduced available effort for all assessment activities.

2. Prepare timely biological advice and recommendations for internal and external clients and service, particularly the biological information needs of, the Zone Management Advisory Committees. Involve external clients where feasible and desirable in the collection of biological data. (Marshall, Amiro, Cutting, O'Neil, Jessop, Ritter)

Prepared stock status report (item 3.1 above) of all SFA's of the region for vetting at CAFSAC and upgraded same to Research Document. Participated in and provided regional CAFSAC and other advice to five zone management committees, area managers and Canada-U.S. boundary water committees and interest groups (St. Croix, the Aroostook and Saint John above Grand Falls), based on counts of salmon by divers, electrofishing of juveniles and adults, counts, age and origin of salmon at fishways and estimates of sport catch. Provided numerous in-season forecasts of end-of-season projected counts at Mactaquac, and advised managers during various salmon allocation negotiations for native food fisheries. Advised and cooperated with numerous sport fishing associations, Indian Bands, corporations/commissions in the execution of various assessment-related projects, e.g., external clients i) operated adult counting facilities in fishways at Beechwood on the main Saint John River, Milltown, Woodland and Grand Falls on the St. Croix River and at the Moncton-Riverview causeway on the Petitcodiac River; ii) were directed in the conducting of biological surveys on the Sackville, Shubenacadie, Big Salmon and St. Mary's (see 3.11) rivers and Eskasoni Brook and creel surveys on the Kennebecasis and main Saint John rivers and iii) assisted in the salmon tracking study (see 3.9). Reduced technical assistance reduced effective deployment of resources.

3. Develop and/or improve pre- and in-season forecast models. (Marshall, Amiro, Cutting)

Investigated the utility of two- and three-variable non-parametric and parametric models to forecast respective 1SW and MSW salmon returns destined for Mactaquac, Saint John River (see 7.iii); and utilized both models for 1992 pre-season forecasts of returns to the Saint John River. Utilized an 18 year data base of cumulative weekly counts and mean monthly river discharges to provide managers with in-season advice (late July through August) on season-end count projections at Mactaquac.

4. Develop models of recreational catch that would enable use of catch as an indicator of stock strength. (O'Neil, Cutting, Jessop, Ritter).

Initiated exploratory analysis but had inadequate resources to provide meaningful output.

5. Participate in initiatives to examine distant interception of Scotia-Fundy Region stocks; formulate and test hypotheses and propose data collections (e.g., indices of change in marine environment, marine growth, sex ratio of smolts) to explain MSW changes in mainland stocks. (Marshall, Ritter, Cutting)

Investigated the error rate in the external sexing of wild and hatchery summer-run grilse to Mactaquac. This should contribute to the reevaluation of sex data submitted to the recently developed MSW predictor model which implicated mean length, mean smolt age and sex ratios of 1SW fish in the subsequent return of MSW salmon. Mean length was the only significant ( $<0.05$ ) variable and supported the hypothesis that marine conditions which contribute to exceptional growth result in more 1SW and fewer MSW returns. The hypothesis would infer, however, that crossover from potential maturation after two winters at sea to maturation after one winter at sea should result in a significant increase in the proportion of females among 1SW returns. Captured and micro-tagged 1,200 wild smolts (4,000 in 1990) in the Beechwood forebays for the study of survival and distant exploitation of wild (as opposed to hatchery) salmon. None of the 1990 tags from Beechwood were returned from commercial sampling programs in distant waters or were among CWTs extracted from 1SW fish at Mactaquac in 1991.

6. Publish the model for determining salmon production capacity of rivers through use of information derived from remote sensing, and complete, if possible, survey information data base for N.B. rivers. Conduct study on parr density and age-at-smoltification, as resources permit. (Amiro)

Submission of the model for publication was preempted by involvement in the ESSA project (see 3.7) and preparation and presentation of a paper dealing with accuracy and precision of juvenile Atlantic salmon population estimates (see 4.2). Technical assistance was inadequate to complete the remote-sensed data base for New Brunswick rivers. Counts of smolts and estimation of their age on Little River (Stewiacke) will be used to complement ongoing studies of density-dependent growth of parr and subsequent age-at-smoltification.

7. Participate in the modelling exercise to assess the effects of acid rain on the production of N.S. salmon stocks. (See Acid Rain Research project for details). (Amiro, Cutting, Marshall)

Contributed a significant data base and analyses on biological parameters to the contract with ESSA (Environmental and Social Systems Analysts Ltd.) to model the effects of acidification on Atlantic salmon. Attempted to enumerate smolt output and measure juvenile densities from the acid-impacted LaHave River for model verification.

8. Set-up image processing system for analyzing scale patterns. (O'Neil, Amiro)

System in place; technical assistance inadequate to initiate projects.

9. Plan, coordinate and conduct the continuing cooperative sonic tagging project for studying adult Atlantic salmon movements and behaviour on the Saint John River. (Marshall)

Multi-sponsored project (item 6i; responsibilities largely carried out by DFO and NB Power) successfully concluded its second and final field season. Data from 1990 and 1991 have been tabulated and verified; exploratory analyses of the 1990 data were provided in a draft preliminary report and a poster on equipment and methodologies was presented at a conference in Aberdeen (see 4.1). Analysis and write-up of the two year study require person resources beyond those committed by DFO or co-sponsors. Observations and preliminary results from ultrasonic tagged fish at and in the vicinity of Beechwood were adequate to convince NB Power to initiate, in 1992, the first phase (\$200K) of a DFO plan to upgrade fish passage at Beechwood Dam.

10. Plan and implement, pending availability of funds, investigations to determine the cause(s) for recruitment failure common to inner Bay of Fundy stocks in four of the past five years. (Amiro)

Held vaccinated and unvaccinated groups of hatchery smolts from the Stewiacke, Moser and Big Salmon river smolts in salt water in a laboratory to ascertain their vulnerability to *Vibrio* - a bacteria ubiquitous to the Bay of Fundy - Scotia Shelf and hypothesized as a possible factor impacting survival of inner Fundy salmon stocks. Released tagged vaccinated and unvaccinated smolts to the Big Salmon, Petitcodiac, and Stewiacke rivers; provided background material on the possible "problems" in inner-Fundy to a Steering Committee comprised of private, DFO science and management personnel for the development of broad-ranging investigative strategies.

11. Direct biological investigations carried out under the pilot "river-specific management" project for the St. Mary's River. (Jessop, Cutting)

Developed, in participation with the St. Mary's River Working Group, a field project for 1991 and coordinated its implementation by H. Kerr, the project biologist hired by the St. Mary's River Association. Less was achieved than was planned for the juvenile electrofishing and angler survey project segments because of the adverse water levels at critical times. A summary of project activities is being prepared by H. Kerr.

12. Develop and prepare required regional input for special CAFSAC investigations, for Canada's input to ICES and for Canada's input to NASCO. (Marshall, Ritter)

As the regional delegates to the ICES Study Group on North American Salmon Fisheries and Working Group on North Atlantic Salmon, described events of the 1991 fisheries in Scotia-Fundy Region and Canada; assisted the Canadian delegation in the development of run reconstruction models of Canadian stocks for input to a North Atlantic (global) model; assisted in the evaluation of the effects of the 1991 quotas in the commercial salmon fishery of Newfoundland and Labrador and provided a Canadian compilation of microtag, finclip and external tag releases. Reviewed U.S. models of Canadian

interception of U.S. stocks, Greenland interception of Canadian stocks and new approaches to assessing interception in distant waters and advised CAFSAC and ICES as appropriate. Lack of any technical assistance reduced overall input.

13. Provide consultation and direction on the choice and use of salmon stocks and on the distribution programs for adult and all stages of juvenile salmon. (Marshall, Amiro, Cutting, Jessop)

Provided advice and directions to the fish culture program involving collection of some 23 salmon broodstocks (personnel and equipment directly involved in some 12 collections), redeployment of 12,000 Saint John adult salmon, and distribution of over two million juvenile salmon, some of which originated in private hatcheries. Released 53,000 micro-tagged hatchery smolts at seven locations in the upper Saint John in the third and last year of a study to assess variable survival and potential for development of areas from which downstream migrants would have to pass through/over hydroelectric facilities.

14. Continue preparation of individual river management plans, to the extent time permits. (Marshall, Cutting, Amiro, Jessop, Ritter)

Provided input to the St. Mary's River Steering Committee and redeveloped with public interest groups, U.S. agencies, provincial government representatives and within DFO, an interim strategy for conservation, enhancement (inc. numbers of adults to be trucked from Mactaquac to the Aroostook and above Grand Falls) for the Saint John River salmon resource above Mactaquac Dam. Advised on closure of inner Fundy rivers to recreational fishing until spawning escapement levels in the Big Salmon River meet conservation requirements.

#### 4. Additional Accomplishments:

1. Marshall promoted the participation of technician J. Cameron (on loan to salmon tracking project) in the 4th European International Conference on Wildlife Telemetry in Aberdeen, Scotland, and assisted in his preparation of a poster "Application of acoustic underwater telemetry to a large high flow river system". He advised the A/DG, and Fredericton area MP, Bud Bird, on the in-season status of Saint John River stocks and assisted in their responses to anglers at a "fed bashing" organized and staged by the NB Salmon Council in the Renous, N.B., arena.
2. Amiro presented a paper entitled "Accuracy and precision of juvenile Atlantic salmon population estimates derived from electrofishing densities using design, model and non-parametric statistical techniques" at the International Symposium on the Production of Juvenile Atlantic Salmon in Natural Waters. He also prepared an article entitled "Inner Bay of Fundy Atlantic salmon stocks - a troubled resource?" for the winter Newsletter of the Nova Scotia Salmon Association. He is the Chairman of the Local Arrangements Committee for the 1994 annual meeting of the American Fisheries Society in Halifax.
3. Cutting supervised the section's presentation before an internal assessment technique review committee comprised of scientists from CAFSAC, Pacific, Capitol and Scotia-Fundy regions of DFO.
4. Ritter prepared and presented a paper on the "Management of the Atlantic Salmon Resource of Saint John River, New Brunswick" at a symposium of the American Fisheries Society in Rhode Island. He is the Science representative on the Canada-U.S. Steering Committee for the development and management of the fish resources of the St. Croix River.

#### 5. Goals/Expected Outputs for 1992:

1. Prepare required assessments of Atlantic salmon stocks to define stock status, such as Saint John, St. Croix, LaHave, Stewiacke, Liscomb, St. Mary's, Grand, Middle and inner Fundy rivers and, where possible, forecast future returns. (Marshall, Amiro, Cutting, Jessop)
2. Prepare timely biological advice and recommendations for internal and external clients and service, particularly, the biological information needs of the Zone Management Advisory Committees. Involve external clients where feasible and desirable in the collection of biological data. (Marshall, Amiro, Cutting, Jessop, O'Neil, Ritter)
3. Continue the investigation of pre- and in-season forecast models, as resources permit. (Marshall, Harvie, Amiro, Ritter)
4. Investigate stock-recruit relationships on acid-impacted rivers (LaHave, Liscomb) and non-acid-impacted rivers (Saint John and Big Salmon) to ascertain optimal spawning requirements. (Marshall, Amiro, Cutting)
5. Investigate models that would enable use of recreational catch as an indicator of stock strength. (O'Neil, Jessop, Amiro, Ritter, Marshall)
6. Participate, as resources permit, in initiatives to examine distant interception of Scotia-Fundy Region stocks; formulate and test hypotheses and propose data collections (e.g., indices of change in marine environment, marine growth, sex ratio of smolts) to explain MSW changes in mainland stocks. (Marshall, Ritter, Cutting)
7. Publish the model for determining salmon production capacity of rivers through use of information derived from remote sensing, and complete, if possible, survey information data base for New Brunswick rivers. Investigate and advise on utility of ESSA model to assess current and potential capacity of the regions rivers to produce salmon. Conduct study on parr density and age-at-smoltification, as resources permit. (Amiro)
8. Participate in the modelling exercise to assess the effects of acid rain on the production of N.S. salmon stocks. (See Acid Rain Research project for details). (Amiro, Cutting)
9. Initiate, as resources permit, projects utilizing the image processing system for analyzing scale patterns. (Amiro)

10. Draft final report, as resources permit, of the two year cooperative sonic-tagging project for studying adult Atlantic salmon movements and behaviour on the Saint John River. (Marshall)
11. Implement investigations, as resources permit, to determine the cause(s) for recruitment failure common to inner Bay of Fundy stocks in recent years. (Amiro)
12. Direct biological investigations carried out under the pilot 'river-specific management' project for the St. Mary's River. (Jessop, Cutting)
13. Develop and prepare required regional input for special CAFSAC investigations, for Canada's input to ICES, and for Canada's input to NASCO. (Marshall, Ritter)
14. Provide consultation and direction on the choice and use of salmon stocks and on the distribution programs for adult and all stages of juvenile salmon. (Marshall, Amiro, Cutting, Jessop, O'Neil)
15. Continue preparation of individual river management plans, to the extent time permits. (Marshall, Cutting, Amiro, Jessop, Ritter)

## 6. Background:

### Highlights:

First outputs from the ESSA modelling exercise promise to show potential of rivers to produce Atlantic salmon under various stages of acidification; continued cooperative spirit exhibited by the numerous non-DFO factions involved in the Saint John River salmon tracking study; a favourable review of Atlantic salmon assessment programs within the division; culmination of a concerted division effort in the provision of advice through CAFSAC on conservation levels, and preliminary estimates of surplus salmon for nearly 20 rivers for which little or no advice had been previously provided.

### Selected Involvements:

#### i. Collaborative Research -

With project biologist hired by the St. Mary's River Salmon Association for the investigation of river-specific management; Nova Scotia DOF in the collection of landlocked salmon for broodstock; NB Power, and to a lesser extent NBDNRE, Water Surveys Canada, Atlantic Salmon Federation, NB Salmon Council, Tobique Indian Band, Fraser's Inc., Town of Hartland, Fredericton and Central branches of the Saint John River Salmon Assoc., Tobique Salmon Protective Assoc., Atlantic Salmon for Northern Maine and Northwest Salmon Association on the Saint John River salmon tracking study; Shubenacadie Indian Band to assess salmon escapement to the Shubenacadie and Stewiacke rivers and a volunteer seeking fisheries work experience in the summary and analyses of data from varied projects.

#### ii. University Liaison -

#### iii. Communications -

Press and radio coverage of various aspects of salmon returns and spawning requirements, usually initiated by a media sensitive to the possibility of over-fishing by Native food fisheries.

#### iv. Contracts Administered -

St. Croix International Waterway Commission to monitor fish traps on the St. Croix River.

#### v. Other -

Collaborated with Kennebecasis River Salmon Association in their conducting of a creel survey; East Richmond Wildlife Assoc. and the Cobequid Salmon Assoc. for assistance on the Grand and Little (Stewiacke) rivers, respectively.

## 7. Publications:

### i. Primary -

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

Amiro, P.G., R.E. Cutting, B.M. Jessop, T.L. Marshall, and S.F. O'Neil. 1991. Status of Atlantic salmon stocks of Scotia-Fundy Region, 1990. CAFSAC Res. Doc. 91/5, 24 p.

Harvie, C.J., and P.G. Amiro. 1991. Forecasts of MSW salmon returns to the Saint John River using non-parametric and parametric models. CAFSAC Res. Doc. 91/22, 19 p.

Marshall, T.L. 1991. Assessment of Atlantic salmon of the upper Saint John River, N.B., 1990. CAFSAC Res. Doc. 91/56, 19 + v p.

### iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

This project was subjected to Peer Review in May. The Review Team gave the project and staff members a very favourable rating. The goals established for 1991, although overly ambitious, were either met or good progress was made. Similarly the goals for 1992 are overly ambitious considering the limited person-year and fiscal resources, and in view that client demands have greatly escalated. Internal clients are seeking more frequent and better advice. As well, the demands on staff members to become involved and often to direct/oversee project activities undertaken by Native bands and angling associations continue to increase. Increased resourcing of this project will be required in 1992 to satisfy client demands and make good progress on the established goals.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 302

Section: Stock Assessment and Enhancement

Project Title: Non-Salmonid Assessment Research

Project Leader: Jessop, B.

Other Researchers: Cutting, R.; Ritter, J.

Work Activity: W.A.1.1.1.1

Key Words: gaspereau; shad; alewife; striped bass; eels; diadromous fish; assessments; assessment research

1. Project Description:

Enumeration and assessment of adult and juvenile stocks and harvests of non-salmonid diadromous species, especially the alewife and blueback herring (gaspereau); preparation of stock assessment documents and advice to managers, and research into improved methodology and expansion of assessments of anadromous (other than salmonids) and catadromous stocks.

2. Long-Term Objectives:

The responsibility for managing anadromous and catadromous fish resources according to current, sound scientific information lies in the Departmental legislated mandate. The long-term objectives of the project are to develop the data base, conduct pertinent analyses, and prepare biological advice on a timely basis for internal and external clients with interests in those diadromous species other than salmonids.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue the enumeration and assessment of the return of alewife and blueback herring to the Mactaquac Dam, Saint John River and to the Milltown Dam, St. Croix River. Achieve designated spawning escapements and supervise the commercial fisheries. Prepare draft manuscripts on the relation between spawning stock size and juvenile abundance index in the Mactaquac Dam headpond, Saint John River, and on the fecundity of alewife and blueback herring from several Maritime rivers. The output will be the escapement and fishery, and progress in manuscript publication and preparation. (Jessop)

All goals in connection with the enumeration, assessment, and control of the spawning escapement of gaspereau (alewife and blueback herring) returning to the Mactaquac Dam, Saint John River were achieved. FHMB managers were advised on the preparation of a three-year management plan for target spawning escapements at the Mactaquac Dam. The draft manuscript on the fecundity of alewives and blueback herring from several Maritime rivers is undergoing internal review and will soon be submitted for journal consideration. Work on the manuscript on the relation between spawning stock size and the juvenile abundance in the Mactaquac Dam headpond will resume when the preceding manuscript has been submitted.

2. Continue the assessment of the downstream movement of juvenile alewife and blueback herring from the Mactaquac Dam headpond. The output will be information relevant to understanding the life history of juvenile Alosa and the interpretation of the juvenile abundance index. (Jessop)

Information on the run timing and biological characteristics of juvenile gaspereau migrating downstream from the Mactaquac Dam headpond was collected between mid-July and late November by means of a net mounted on a stationary barge. The data will be integrated with existing data on juvenile life history.

3. Continue assessment of the run timing of American eel elvers to the East River, Sheet Harbour, and collection of biological data on the run. After the third year of data collection, a report will be prepared. (Jessop)

A third and final year of data was collected on the run timing, abundance, and biological characteristics of the elvers returning to the East River, Sheet Harbour. Report preparation will begin as soon as feasible.

4. Continue the American eel age verification study by assessing the survival of transplanted elvers and collecting samples for ageing. The output will be development of a time series of samples of American eels of known age. (Jessop)

A reduction in project budget and in the availability of helicopter time resulted in cancellation of the plan to electrofish the lakes previously stocked with elvers. A further effort to obtain eel growth data will be made in 1992 if helicopter time can be obtained.

5. Complete preparation of a draft report on fecundity of alewife and blueback herring in several Maritime rivers. The output will be a publication. (Jessop)

A draft report on fecundity of alewives and blueback herring in several Maritime rivers has been completed and is in internal review prior to revisions and submission to a journal.

6. Complete preparation of a draft report on the seasonal marine distribution of alewife and blueback herring in Scotia-Fundy Region. The output will be a publication. (Jessop)

The manuscript on seasonal marine distribution of alewife and blueback herring in Scotia-Fundy Region has been accepted by a journal, pending final revisions.

7. Provide biological and technical advice to fishery managers on gaspereau, American shad, striped bass, American eel, shortnose sturgeon, and other non-salmonid diadromous fish resources. The output will be timely, sound, scientific information based on the data current at the time of response. (Jessop, Cutting, Ritter)

An increasing number of requests for biological and technical advice on the non-salmonid diadromous species were effectively handled for internal and public sector clients. Advised FHMB managers on preparation of a regional striped bass management plan. Leader participated in advisory committees as required.

#### 4. Additional Accomplishments:

1. Collected additional catch and biological data on gaspereau by-catch in marine fish survey cruises for examination of feeding activity of gaspereau. A data base was assembled on survey cruise by-catch of American shad.
2. Initiated a survey of the commercial catch composition of American eels in two locations of the lower Saint John River at the request of the Eel Fishery Advisory Committee. Developed a cooperative project with a UNB professor to permit a summer COSEP student to use a part of the collected data for an undergraduate honors thesis. Data entry to computer has largely been completed except for age data which remains to be obtained from otolith analysis.
3. Reanalyzed the data from a survey of the gaspereau runs to five rivers in Nova Scotia and wrote a report that is now in the final stages of editorial approval for the Manuscript Report series.

#### 5. Goals/Expected Outputs for 1992:

1. Continue the enumeration and assessment of the return of alewife and blueback herring to the Mactaquac Dam, Saint John River and to the Milltown Dam, St. Croix River. Achieve designated spawning escapements and supervise the commercial fisheries. (Jessop)
2. Complete data analysis and summarize results of the assessment of downstream movement of juvenile alewife and blueback herring from the Mactaquac Dam headpond. (Jessop)
3. Complete data analysis and begin preparation of a report on the run timing and biological characteristics of American eel elvers to the East River, Sheet Harbour. (Jessop)
4. Complete analysis of stomach contents of gaspereau collected in marine fish surveys, analyze data, and draft report. (Jessop)
5. Begin ageing of American eel otoliths collected in the survey of the commercial fishery in the lower Saint John River. This task may be of extended duration because of its time-consuming nature and the possible higher priority of other tasks. (Jessop)
6. Resources permitting, continue the American eel age verification study by collecting otoliths from samples of transplanted, known-age eels for age analysis. (Jessop)
7. Complete a report and submit for journal consideration a paper on the relation between spawning stock size and the juvenile abundance index of alewives and blueback herring returning to the Mactaquac Dam headpond. (Jessop)
8. Provide biological and technical advice to fishery managers on gaspereau, American shad, striped bass, American eel, shortnose sturgeon, and other non-salmonid diadromous fish resources. The output will be timely, sound, scientific information based on the data current at the time of response. (Jessop, Cutting, Ritter)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

Leader is a core member of the Statistics, Sampling and Survey Subcommittee (CAFSAC).

##### ii. University Liaison -

Leader is supporting COSEP student research in cooperation with student's university professor.

##### iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Jessop, B.M. 1991. The history of the striped bass fishery in the Bay of Fundy. In R. Peterson (ed.) Proceedings of the Striped Bass Workshop, St. Andrews, N.B., September 10, 1990. Can. Tech. Rep. Fish. Aquat. Sci. No. 1832.

Jessop, B.M., and W.E. Anderson. 1991. List history data on the alewife and blueback herring, Mactaquac Dam, 1982-1988. Can. Data Rep. Fish. Aquat. Sci. No. 829, 42 p.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to be very productive both in producing new science and in providing biological advice for the management of the non-salmonid diadromous fish resources of the Scotia-Fundy Region. The demands for advice to manage species other than alewife and blueback herring will continue to increase in 1992 as will the requirements to expand biological investigations to encompass more stocks and species. Most prominent on the list of new species requiring greater attention is the striped bass for which Gulf and Scotia-Fundy regions are in the process of establishing a new management regime.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 303

Section: Stock Assessment and Enhancement

Project Title: Salmon Enhancement Research (Enhancement Biology)

Project Leader: Cutting, R.

Other Researchers: Amiro, P.; Farmer, G.; Jansen, H.; Jessop, B.; Marshall, L.; O'Neil, S.; Ritter, J.

Work Activity: W.A.1.1.2.4

Key Words: salmon enhancement; hatcheries

1. Project Description:

The project involves the identification, planning, implementation, and assessment of Atlantic salmon enhancement projects. Expertise in biology, engineering, and fish culture are coordinated to increase salmonid production for the commercial, recreational and Native food fisheries. Major activities are: identification of suitable projects, development of enhancement techniques, integration of engineering services and fish culture production output with project needs, monitoring of stocks under development, and provision of senior biological advice to planning and implementation of salmon enhancement programs.

2. Long-Term Objectives:

Increase Atlantic salmon production by using enhancement technology in conjunction with other resource management and habitat protection efforts. The enhanced production can be used to: expand the recreational fishery, increase commercial landings, and satisfy authorized food fishery requirements of Native communities.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue to operate the LaHave and Liscomb River Atlantic salmon enhancement projects, especially for their assessment data bases. (Jessop, Cutting)

Enumerations and field activities were undertaken on the LaHave and Liscomb rivers to continue project evaluations. Fishway counts and biological parameters were inserted into the on-going time series data bases. This information base was used (Project 301) in developing regional status reports and stock assessments which appear in CAFSAC documentation. Equipment was assembled for smolt enumeration on the upper LaHave River but efforts to capture smolts failed because of exceptionally high water.

2. Implement the activities associated with the plan to rehabilitate the Petitcodiac River salmon stock. (Amiro)

Tentative plans for evaluating the salmon smolt migration pattern in the Moncton causeway area were obviated by the opening of the causeway gates during the smolt period. Spawner returns were so low that the planned collection of broodstock by electrofishing was deemed a fruitless exercise, though a few fish were captured in the fishway trap. Small numbers of surplus parr stock at the Salmon Research Centre were released into the drainage.

3. Undertake and collaborate on the collection of the salmon broodstock for the fish culture program. (Amiro, Farmer, Cutting)

Salmon broodstocks were collected at enumeration facilities at East River (Sheet Harbour), LaHave, Liscomb, Medway, Petitcodiac, Saint John, and Tusket rivers, and by seining or electrofishing on the Annapolis, Gold, Grand, Hammond, Kennebecasis, Musquodoboit, Nashwaak, North, River Philip, Salmon (Mira), Salmon (Digby), St. Mary's, and Stewiacke rivers in joint operations with staff of the Fish Culture Section. Operation of the Petitcodiac River enumeration facility was carried out by a volunteer from the N.B. Wildlife Federation.

4. Coordinate the biological, engineering and private sector inputs to the Atlantic salmon development project for the Saint John River above Grand Falls. (Ritter, Marshall)

Coordination was carried out externally through a few meetings and many phone consultations with external clients. Though neither internal nor external funding for facilities construction, were available, engineering planning was developed and carried as far as permitted by present information. Collaborated with the private sector and U.S. officials in the allocation and transfer of eggs, juveniles, and adult salmon above Grand Falls and to the Aroostook tributary; trucked 367,000 fall fingerlings and 140 adults above Grand Falls and 100 adults above Tinker Dam on the Aroostook River.

5. Direct the development of the Atlantic salmon and gaspereau resources of the St. Croix River, N.B., and coordinate activities with U.S.A. officials. (Marshall, Jessop, Ritter)

Participated in the St. Croix River Steering Committee meetings to achieve coordination with U.S.A. officials. Operation of enumeration facilities was conducted by contract to the St. Croix International Waterways Commission by joint funding by DFO and Georgia-Pacific Corp., a Maine industry. Contributed to development of a three-year management plan for the gaspereau commercial fishery at the Milltown Dam, implemented in 1991. Coordinated collection of fishway counts and biological data on the gaspereau run done under contract by the St. Croix International Waterway Commission. Reviewed the engineering proposals for improvements to upstream and downstream fish passage at three main stem dams. The withdrawal of active involvement of the Maine Atlantic Sea-Run Salmon Commission in activities provides an opportunity for DFO to review current successes and to evaluate future direction of the salmon development program for the St. Croix.

6. Prepare a comprehensive salmon development proposal for the Sackville River. (O'Neil)

Contributed in a major way toward an inter-departmental (DFO-Environment) report on the salmon enhancement potential of the Sackville River, for publication in the new fiscal year.

Coordinated extensive habitat-related and fish stocking activities on the Sackville River (by working closely with a volunteer organization) as part of a long range restoration program.

#### 4. Additional Accomplishments:

1. Several recreational organizations in both N.B. and N.S. assisted with distribution and stocking of hatchery-reared salmon fry and parr.
2. Collaborated with FHMB and N.S. Power Corporation, using CEF consultant, toward developing a fisheries development plan for the lower Mersey River. (Ritter, Cutting)
3. On behalf of Science Branch, played a key planning and coordination role in the design and rationalization of the recreational fisheries initiative as affecting regional fish resources. (Ritter)

#### 5. Goals/Expected Outputs for 1992:

1. Continue to operate the LaHave and Liscomb rivers Atlantic salmon enhancement projects, especially to continue their valuable assessment data bases and, in the case of Morgan Falls, to monitor fish movements in the face of an imminent hydropower development. (Jessop, Cutting)
2. Undertake and collaborate on the collection of the salmon broodstock for the fish culture program. (Amiro, Farmer, Cutting)
3. Coordinate the biological, engineering, and private sector inputs to the Atlantic salmon development project for the upper Saint John River, i.e., the Aroostook River and the main river above Grand Falls. (Ritter, Marshall)
4. Direct the development of the Atlantic salmon and gaspereau resources of the St. Croix River, N.B., and coordinate activities with U.S.A. officials. (Marshall, Jessop, Ritter)
5. Coordinate the salmon development for the Sackville River, N.S., and carry out related field activities. (O'Neil)

#### 6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -

Information from projects is routinely used for stock assessments, for evaluating fish culture practices, and for apprising external clients interested in current project development. Communications related to the upper Saint John River salmon development involved briefing documents, exchanges with State of Maine officials, upper basin meetings, planning documentation, and seedstock reallocations.

iv. Contracts Administered -

v. Other -

Participated in the Annapolis Valley Rivers Committee interested in redeveloping fisheries resources for the people of the valley. (Cutting)

#### 7. Publications:

- i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Semple, J. Richard. 1991. Atlantic salmon habitat survey: enhancement opportunities and problems in the Dunbar Stream, Nashwaak River, New Brunswick. Can. MS. Rep. Fish. Aquat. Sci. 2076, 35 p.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project provides a focus and direction for many of the Division's activities. It also contributes information that is used in stock assessments and to evaluate hatchery performance. Fiscal and person-power limitations restrict expansion of enhancement initiatives for which demands from recreational and Native fishermen continue to increase. Public interest in becoming involved in enhancement is also increasing, but no new A-base resources are available to cope with this growing demand. Although existing staff are stretched to the limit in the Division's attempts to respond to and work with the numerous public interest groups, this situation will worsen if major new funds are made available for the Recreational Fisheries Initiatives Programs under consideration for N.S. and N.B.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 304

Section: Engineering Services

Project Title: Enhancement and Fish Passage Engineering

Project Leader: Jansen, H.

Other Researchers: Conrad, V.

Work Activity: W.A.1.1.2.4

Key Words: fish passage; mitigation; salmon enhancement; fishways

1. Project Description:

Provides engineering technology required to operate and maintain existing Department-owned enhancement facilities (\$3M replacement value). Involves planning, design, and construction of new enhancement projects consisting of habitat restoration or improvement, and fish passage facilities. Provides engineering services to the Fisheries and Habitat Management Branch.

2. Long-Term Objectives:

Maintain, restore and expand freshwater and anadromous fish production for the commercial, recreational and Indian food fisheries by the use of enhancement technology in conjunction with other resource management and habitat protection efforts.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

(Note that projects with \* require funding over and above Division A-base.)

1. Complete the engineering aspects of planning future year projects as follows: (a) detailed design and contract documents for the proposed fishway for Grand Falls, St. John River; (b) functional design of improvements for Beechwood hydroelectric station fish passage facilities; (c) site survey of Gorden Falls, Pollet River, N.B.; (d) design of a downstream fishway for the Marshall Falls, NSPC storage dam; (e) continue with St. Mary's River flow control study; (f) preliminary investigation of downstream fish passage facilities at Tobique Hydroelectric Station. (Conrad, Jansen)

(a) Functional designs for a fishway and a trapping and trucking alternative were completed. Proposals for a geological-engineering study were received, however, funds were not available to proceed. (b) Completed. (c) Postponed to next season (staff not available when flows were low). (d) Completed. (e) Continuing. (f) Initiated; further work required next year.

2. Follow-up investigations of previously completed projects as follows: (a) Tobique Narrows fishway; (b) entrance problems at White Rock fishway; (c) fish passage problems at St. George, N.B. (Conrad, Jansen)

(a) Biological monitoring continuing. (b) Improvements by NSPC requested. (c) Implemented successfully by J.D. Irving.

3. Project administration and/or site supervision of construction projects as follows: (a) fishway assessment facilities and roadway improvements at Grand River, N.S.; \*(b) fish trapping facilities at St. George fishway; \*(c) Phase I of Grand Falls, St. John River, fishway construction; (d) fishway improvements at East River, Sheet Harbour, N.S.; (e) modification to Morrison Brook, N.S. culvert. (Conrad)

(a) No funds. (b) Construction drawings completed. (c) No funds. (d) No funds. (e) Fabrication completed; install next season.

4. Update the fishway inventory. (Conrad)

Completed and circulated to C&P field personnel for input on inspections. There are now 255 fishway installations including 39 culverts with special features for fish passage.

5. Provide engineering services to Fisheries and Habitat Management Branch consisting of the development of acceptable fish passage designs and negotiations with proponents of water-use projects to meet the requirements of Section 20 of the Fisheries Act. Also included are negotiations with owners of existing fish passage facilities for improvements. (Conrad, Jansen)

A. Functional designs of fishery protective measures were completed for the following water development projects: (a) A water supply dam for a gravel washing operation on Parks Brook, N.B. (b) A hatchery water supply dam on Cripps Stream, N.B. (c) Baffled highway culverts on Baker

Brook, N.B. (d) Small hydro development at Morgan Falls, N.S. (e) Small hydro development at West River, Sheet Harbour. (f) Hydro redevelopment at St. George, N.B. (g) Water level control dams at two sites on the Shubie Canal.

B. Ministerial approval of final construction drawings were given for fish passage facilities proposed at: Chamcook Lake by ASF, at Grafton Lake by Parks Canada, and for downstream facilities and improved upstream attraction at Woodland and Grand Falls (St. Croix River) by Georgia Pacific.

C. Improvements to existing facilities implemented at the following locations: in Nova Scotia - Truman Pond (new baffles); Sydney River (new baffles and concrete repairs); Sherbrooke Lake (downstream facilities); Chaswood Meadows (baffle repairs); Rhodenizer Lake (fishway modifications); Shorts Beach (new chutes added); Harmony Mills (pipeline extension and baffle improvements); Greenwood Lake, Indian Brook (screens and weir added). In New Brunswick - Beechwood collection gallery (minor improvements); Hillsboro Marsh (baffles adjusted); Peters Brook (rock excavation).

6. Applied research on engineering aspects of habitat improvements and restoration techniques in cooperation with the Stock Assessment and Enhancement Section, the Area Managers, Fishery Officers, and the Habitat Management Branch; (a) feasibility study of installing fish passage on the North Magaguadavic River at the Woolen Mill dams; (b) fish passage and flow requirements on the lower Nictaux River, N.S.; (c) fish passage at the dam on Paper Mill Lake, N.S.; (d) fish passage at Parrsboro River causeway; (e) fish passage improvements in tidal area of Salmon River, Digby Co., N.S.; (f) additional items requiring priority action will be identified during the year. (Conrad, Jansen)

(a) Carried forward to next year. (b) Flow data collected and working with NSPC for flow release options. (c) Preliminary feasibility study shows marginal benefits. (d) Design completed and owner requested to construct. (e) Completed. (f) Fishway for Mill Creek project. (g) Feasibility study and cost estimates for fishways at a waterfall and several dams on the Meteghan River. (h) Rerouting of fish on the Gaspereau and Black rivers with the turbines down. (i) Fishway for existing Arnold Lake Dam. (j) Fishway for existing East Loon Lake Dam.

#### 4. Additional Accomplishments:

1. Design of commercial alewife harvesting equipment for Milltown N.B. fishway.
2. Investigation and report on salmon injuries observed at Mactaquac fish collection facility.
3. River survey at Gaspereau River dipping stand for court evidence.
4. A draft report Evaluation of the Water Storage Potential of Lakes on the St. Mary's River Drainage Basin and the Effect of Controlled Release on Flow Parameters During Low Summer Flow was completed.
5. Participated in an international workshop in St. John's, Newfoundland on fishery protective methods at hydroelectric projects.
6. Information exchange with visitors: Prof. Tuan from Taiwan and Stephen Gephard from Connecticut.
7. Provided advice on fish passage or handling facilities for projects in Quebec; Newfoundland; Lawrence; New Hampshire; North Esk River, Scotland.
8. Topographic survey of tidal area of Jordan River and design of proposed salmon angling pool(s).
9. Unpublished briefing document Hydrology and River Hydraulics Sackville River, N.S.

#### 5. Goals/Expected Outputs for 1992:

(Note that projects with \* require funding over and above Division A-base).

1. Complete the engineering aspects of planning future year projects as follows: \*(a) Geological-engineering investigation of the Grand Falls fishway route for rock stabilization and complete functional design and costing of the fishway and trapping-trucking alternatives. (b) Site survey of Gorden Falls, Pollet River, N.B. (c) Continue with St. Mary's River flow control study. (d) Additional attraction water and fishway entrance improvements at Tobique fishway. (e) Preliminary investigation of downstream fish passage facilities for Tobique Hydroelectric Station. (f) Investigate fish passage efficiency of alewives at Tusket (3 sites), White Rock and Milltown. (g) Functional design of replacement fishway at NSPC Tusket Diversion Dam.
2. Design, project administration and/or site supervision of construction projects as follows: \*(a) Phase I of Grand Falls, St. John River, fishway construction. (b) Morrison Brook, N.S. culvert modifications. (c) Install two weirs in channel downstream of fishway at Ruth Falls. (d) Minor improvements to Sackville River fishway. (e) Elver trapping at Mactaquac. (f) Smolt trapping facilities LaHave River. (f) Solve problem at highway culvert at Lochaber Lake.
3. Update the fishway inventory.
4. Provide engineering services to Fisheries and Habitat Management Branch consisting of the development of acceptable fish passage designs and negotiations with proponents of water-use projects to meet the requirements of Section 20, 21, 22 and 30 of the Fisheries Act. Also included are negotiations with owners of existing fish passage facilities for improvements. (Conrad, Jansen)
5. Applied research on engineering aspects of habitat improvements and restoration techniques in cooperation with the Stock Assessment and Enhancement Section, the Area Managers, Fishery Officers, and the Habitat Management Branch: (a) fish passage at Woolen Mill dams on the North Magaguadavic River, N.B. (b) Typical dam-fishway layouts. (c) Preliminary fish screening

tests. (d) Additional items will develop during the year. (Conrad, Jansen)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Most of the scheduled activities were completed, and the few that were not completed were deferred for good reasons. Major improvements or developments in fish passage are dependent on outside sources of funding, which in general have not been declared this far in advance of the actual activity.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 305

Section: Engineering Services Section

Project Title: Fish Culture Engineering

Project Leader: Jansen, H.

Other Researchers: Hubley, P.

Work Activity: W.A.1.1.2.4

Key Words: hatcheries; salmon enhancement; aquaculture

1. Project Description:

Provides engineering technology required to operate and maintain existing hatcheries (\$20M replacement). Plans, designs and constructs new hatchery facilities or modifies, improves, and expands existing facilities where technically feasible. Provides technical feasibility reviews of private and other government hatchery proposals and ad hoc advisory services to aquaculture operations.

2. Long-Term Objectives:

Expand Atlantic salmon production from the Region's fish culture facilities for the commercial, recreational and Indian food fisheries.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

(Note that projects with \* require funding over and above Division A-base.)

1. Complete the engineering aspects of planning for future year projects as follows: \*(a) Mactaquac FCS - investigate problem of low yield from well #5. (b) Mactaquac FCS - complete material lists and cost estimates for additional phases of modification of rearing ponds, and design of permanent repairs to ponds and flumes in spawning building. (c) Cobequid FCS - carry out additional design work for new supply & drainage pipes, improvements to dam and new or renovated hatchery buildings. (d) Coldbrook FCS - investigate feasibility of deepening existing circular ponds by extending/raising walls. (e) Mactaquac FCS - investigate the feasibility and practicality of sterilizing the hatchery water supply. (Hubley, Jansen)

(a) Unfunded; deferred to next year. (b) Completed. (c) Partially completed; to be continued next year. (d) Completed. (e) A low capital cost iodine treatment proposal appears to have potential.

2. Update the long-term minor maintenance plan and complete work on several items from the plan as funds permit. (Hubley)

(a) At the Mactaquac Accelerated Rearing Facility installed 60 additional trusses to reinforce two of the greenhouses. (b) Installed new furnaces at Mactaquac, Cobequid and Coldbrook. (c) At Cobequid FCS installed a fully operational washroom and sewage disposal field to replace a chemical toilet; labour supplied with a Corrections Canada-CEIC job training project. (d) Several minor projects completed at all of the hatcheries.

3. Continue with the planning of a preventative maintenance program for mechanical equipment. (Hubley, Jansen)

No time was available due to the many construction projects.

4. Proceed with project administration and/or site supervision for several construction projects as follows: \*(a) Saint John FCS - construction and/or installation of 8 - deep 25' swede ponds or 10 - deep 25' circular ponds and associated piping and site work. \*(b) Mactaquac FCS - construction/modification of 11 additional deep 36' swede ponds and associated piping and work to overhead doors. (c) Mactaquac FCS - completion of visitors facilities, e.g. additional landscaping, pavement marking, fabrication and installation of displays, construction of handrails and seats or rest areas, miscellaneous painting, installation of site furnishings and changing colour of FRP brailles in dump and holding ponds at sorting building to improve visibility of fish. \*(d) Mactaquac FCS - installation of predator netting. \*(e) Mactaquac FCS - painting of metal roofs and structural steel supports of pond buildings. \*(f) Cobequid FCS - construct concrete dividers in another row of earth ponds. \*(g) Cobequid FCS - Modify 6 - 25' Ø circular ponds by raising their walls, repairs to their floors and associated work to supply and drain piping. \*(h) Yarmouth FCS - repair dam as required by the Town of Yarmouth, carry out other work to close out the hatchery. \*(i) Carry out phase II of a four-year program to replace fuel storage tanks at the hatcheries to ensure compliance with the National Environmental Code

of Practice for Underground Storage Tank Systems Containing Petroleum Products 1989. (Hubley, Jansen)

(a) Completed 8 - 25' x 4' deep swede ponds and partially completed additional 8 ponds with labour provided by a CEIC job creation project sponsored by the Kennebecasis Salmon Association. (b) Completed with labour provided by a CEIC job creation project sponsored by the N.B. Wildlife Federation. (c) Completed with a Grand Opening on June 25. (d) No funding available, however, design was completed. (e) Completed pressure washing and primer coat of paint on roof with no painting of structural steel. (f) With labour supplied by a combined Corrections Canada CEIC job training project sponsored by the Cumberland Rivers Association, completed reconstruction of concrete dividers in two rows of earth ponds rather than the one row scheduled. (g) Funds not available/deferred to next year. (h) On hold due to uncertainty of closure. (i) Funds not available.

\*5. Complete additional health and safety improvements at the fish culture stations as funds permit, with special emphasis on upgrading electrical systems. (Hubley)

At Saint John FCS, with Capital Assets funding, completed most of the refurbishing of the electrical system for the entire site. Also included was a second exit from the main hatchery attic, replacement of the flammable wall materials and windows in the office area. A fire rated furnace room was constructed by the CEIC job creation crew.

4. Additional Accomplishments:

1. At Mactaquac FCS reattached 31,622 ft<sup>2</sup> of metal roofing which was loose because the screws were pulling out of the rotten wood (also replaced and rebolted) on the steel purlins with four summer students.
2. At Mactaquac FCS a facility to sort undesirable fish species from those to be trucked to upriver areas.
3. A feasibility study and cost estimates of several potential systems for microstraining Cyclops scutifer, the first intermediate host of the gull worm parasite, from the Yarmouth FCS water supply.

5. Goals/Expected Outputs for 1992:

(Note that projects with \* require funding over and above Division A-base).

1. Complete the engineering aspects of planning for future year projects as follows: \*(a) Mactaquac FCS - investigate problem of low yield from well #5. (b) Continue with design of refurbished fish rearing facilities for Cobequid FCS. (c) Mersey FCS - construction drawings and cost estimates for installation of a central pH adjustment facility and a 32" main pipeline.
2. Update the long-term minor maintenance plan and complete work on several items from the plan as funds permit.
3. Continue with the planning of a preventative maintenance program for mechanical equipment.
4. Proceed with project administration and/or site supervision for several construction projects as follows: \*(a) Saint John FCS - complete the 8 - deep 25' swede ponds which were partially completed last year. \*(b) Mactaquac FCS - painting of roof and structural steel. \*(c) Mactaquac FCS - construction/modification of nine deep 36' swede ponds and associated piping and work to overhead doors. \*(d) Cobequid FCS - modify 5 - 25' Ø circular ponds by constructing new deep walls and a new drainage and water supply lines. \*(e) Yarmouth FCS - depending on the decision to close or open, proceed with the modification required. \*(f) Mersey FCS - construct flood protection dyke and bury 12" Ø pipeline under the spillway channel. \*(g) Saint John FCS - construction/modification of eight deep 25' swede ponds and associated piping. \*(h) Mactaquac FCS - modify fish sorting facility for removing undesirable species.
5. Complete additional health and safety improvements as funds permit. The major item is the replacement of fuel storage tanks at several hatcheries to comply with the National Environmental Code of Practice for Underground Storage Tank Systems Containing Petroleum Products 1989.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Members of the Engineering Services Section have been very proficient at maximizing the expenditure power of the limited resources available for maintenance and upgrading of the Division's fish culture facilities which have a replacement value of more than \$20 million. They have once again been very resourceful in acquiring funds and labour from outside the Region's A-base, e.g., Capital Assets, CEIC Section 25, Correction Services Canada. As a result of their activities, all facilities are operational and major upgrading of the Division's fish culture facilities is proceeding in phases. Unfortunately, current budgetary restraints and cutbacks are making it increasingly difficult to continue with the upgrading of facilities using non-A-base funds. An increase in A-base funds is required (as seed money to attract and effectively utilize CEIC and other B-base funds) to continue the upgrading of the Division's hatchery facilities at the current rate.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 306

Section: Stock Assessment and Enhancement

Project Title: Finfish and Invertebrate Introductions and Transfers

Project Leader: Cutting, R.

Other Researchers: Ritter, J.

Work Activity: W.A.1.1.1.1

Key Words: introductions; transfers

1. Project Description:

Provides focus for review and coordination of Regional matters pertaining to the introductions and transfers of finfish and invertebrates and for coordination of the Division's involvement in assessing the impact of aquaculture on wild salmonid populations.

2. Long-Term Objectives:

Coordinate Divisional and Regional (as required) assessments of introductions and transfers of marine organisms.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide Regional and Canadian representation for required inputs to Regional, national, ICES, and NASCO groups regarding introductions and transfers of marine organisms, especially salmonids. (Cutting)

Solicited federal and provincial inputs and assembled the Canadian national report for the ICES Working Group on Introductions and Transfers of Organisms annual meeting. Provided Canadian editorial input to Canadian sections of the ICES Cooperative Research Report on Introductions and Transfers scheduled for publication in 1992. As chairperson of the Regional Non-Indigenous Species Introductions Committee, coordinated and expedited the preparation of advice, recommendations, or written permissions for proposals for the movement of aquatic organisms with possible impact on native populations. Those fish movements addressed species as varied as Arctic charr, Atlantic salmon, American eel, striped bass, bay scallop, brook trout, giant scallop, Icelandic scallop, horseshoe crab, and prawns (sand shrimp, white shrimp, and tiger shrimp). Maintained the U.S.A.-Canada combined inventory of salmonid introductions and transfers in eastern North America for the Scientific Working Group on Introductions and Transfers of Salmonids, a bilateral unit of the North American Commission of NASCO.

2. Promote and coordinate studies to identify and evaluate the impacts of the N.B. salmon aquaculture industry on local wild salmon stocks. (Ritter, Cutting)

Collaborated with the Atlantic Salmon Federation in the development of a proposal for studying the possible impacts of aquaculture on N.B. wild salmon populations. Assisted a visiting Irish scientist with the collection of salmon tissue materials for study of this issue. Collected and reviewed current publications on this subject, principally by ICES and NASCO.

4. Additional Accomplishments:

Participated in the development of a national registry for aquaculture stocks. (Ritter)

5. Goals/Expected Outputs for 1992:

1. Provide Regional and Canadian representation for required inputs to Regional, national, ICES, and NASCO groups regarding introductions and transfers of marine organisms, especially salmonids. (Cutting).
2. Promote and coordinate studies to identify and evaluate the impacts of the salmon aquaculture industry on local wild salmon stocks. (Cutting, Ritter)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Outputs are the documents required by Regional administration or clients, draft correspondence or advice needed by senior levels in DFO, and input to ICES and NASCO requirements on introductions and transfers.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

All the goals of this project were met in 1991. Limited AFAP funding is being made available to the Atlantic Salmon Federation to initiate in 1992 a collaborate project with DFO to investigate the impacts of N.B. aquaculture escapees on the nearby Magaguadavic wild salmon population. The Division will work with the Federation to guide the project and to oversee a part of the field activities.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 308

Section: Fish Culture

Project Title: Hatchery Operations and Production

Project Leader: Farmer, G.

Other Researchers: Aitken, D.; Austin, W.; Goff, T.; McAskill, J.; Penney, G.; Young, E.; Dunfield, R.

Work Activity: W.A.1.1.2.4

Key Words: aquaculture; Atlantic salmon enhancement; hatcheries

1. Project Description:

Juvenile anadromous Atlantic salmon produced at six hatcheries and landlocked salmon at one hatchery are distributed to public waters for enhancement purposes. Atlantic salmon smolts and parr are sold as seedstock to the aquaculture industries in N.S. and N.B. and are available for private, university and government research. Trapping and trucking operations for gaspereau and adult salmon are carried out on the Saint John River, N.B. Technical advice on salmonid culture methods and facilities are provided routinely to private aquaculturists.

2. Long-Term Objectives:

Support public fisheries and the stocks upon which they depend. Encourage and support the development of salmonid aquaculture industries in N.S. and N.B.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Meet all hatchery production targets as outlined by salmon enhancement biologists. (Farmer)

Twenty-two discrete stocks of anadromous Atlantic salmon were reared at Scotia-Fundy hatcheries for stock enhancement purposes. The 105,000 salmon fry, 775,000 parr and 755,000 smolts distributed in 32 rivers during 1991 satisfied production targets.

2. Support the salmon aquaculture industries in N.B. and N.S. through the provision of technical advice and stock for broodstock development. (Farmer, Goff, Aitken, McAskill)

Thirty thousand Saint John River 1+ smolts were produced at the Saint John Hatchery for the New Brunswick Salmon Growers broodstock development program which is being conducted as part of the Salmon Genetics Research Program. Twenty-two thousand LaHave, River Philip and Saint John 1+ smolts produced at the Mersey Hatchery were supplied to three sea cage operators in Nova Scotia during 1991 as part of an industry broodstock development program. The performance of the smolts supplied to the Nova Scotia industry during 1990 was assessed and the results reported to industry members. Fifty thousand Saint John 1+ smolts produced at the Mactaquac Hatchery were supplied to a number of sea cage operators in New Brunswick to help alleviate a shortage of private-sector smolts. Fifteen thousand 1+ Saint John smolts produced at the Saint John Hatchery were provided to the Salmon Demonstration and Development Farm operated by the New Brunswick Salmon Growers Association for research purposes.

3. Improve smolt quality as measured by a quality index. (Farmer)

Sixty-five percent of the 1+ smolts and 85% of the 2+ smolts produced at Scotia-Fundy hatcheries were observed to be of good quality. Research has shown that the necessary improvement in smolt quality will require the replacement and/or modification of outmoded rearing ponds at the Mactaquac, Saint John and Cobequid hatcheries. Considerable improvements to the ponds at these locations were carried out during 1991.

4. Carry out trapping and trucking operations for adult salmon and gaspereau returning to the Mactaquac hydro dam on the Saint John River. (McAskill)

A total of 11,801 adult Atlantic salmon were captured at the Mactaquac Dam on the Saint John River and then transported to the Mactaquac Hatchery for sorting and the collection of biological information. Approximately 400 adult salmon were retained for broodstock purposes and the remainder transported to release sites located above the Mactaquac Dam to satisfy the recreational fisheries and spawning escapements. Adult salmon were released in the main Saint John River at Woodstock and above Grand Falls and in the Tobique and Aroostook tributaries. Two hundred and seventeen tonnes of gaspereau were collected at the Mactaquac Dam for the commercial harvest and 896,000 gaspereau transported to the Mactaquac headpond to satisfy the required spawning escapement.

5. Continue to work toward increasing public awareness of ongoing programs of DFO and the fishery resources of the Scotia-Fundy Region. (Ritter, Farmer)

The Mactaquac Visitor Facility was officially opened during June. Guided tours of the hatchery are provided to the public and feature the viewing of juvenile and adult Atlantic salmon as well as other species of freshwater and anadromous fishes. Displays and written material are available to explain Atlantic salmon biology, salmon enhancement and management programs and fish culture techniques.

Several recreational fisheries organizations participated in the incubation of salmon eggs and/or the distribution of fry or hatchery parr within the rivers they have specific interest in (e.g., Gold, Musquodoboit, East Sheet Harbour rivers, N.S.; Upper Saint John, Salmon, Tobique, Meduxnekeag, Kennebecasis rivers, N.B.).

6. Close operations at the Yarmouth Hatchery and dispose of the facility through CADC. (Ritter, Farmer, Young)

Salmon rearing operations at the Yarmouth Hatchery were terminated with the April distribution of salmon smolts. One staff member has retired and the other is on assignment with the Fisheries and Habitat Management Branch. DFO staff have met with recreational fisheries organizations located in Shelburne, Yarmouth and Digby counties, N.S., to develop a salmon enhancement plan for southwestern N.S. The report which has been developed contains details of the salmon enhancement plan and compares the costs of providing the required hatchery parr and smolts from the Yarmouth Hatchery or alternately from the Mersey Hatchery located in Queens Co., N.S. It is expected that a decision on the future of the Yarmouth Hatchery will be made early in 1992.

#### 4. Additional Accomplishments:

Supplied Atlantic salmon eggs to: (a) Ontario Ministry of Natural Resources for their Lake Ontario restoration program; (b) Aqua Health Ltd., P.E.I., for the development of vaccines; (c) SALEN, the public group which leases the Florenceville Hatchery, for their upper Saint John River enhancement program; (d) three recreational fishing groups to conduct egg incubation studies on the Saint John River, N.B. and (e) numerous government and university scientists for their research.

#### 5. Goals/Expected Outputs for 1992:

1. Meet production targets for juvenile hatchery salmon specified by salmon enhancement biologists. (Farmer)
2. Support the salmon aquaculture industries in N.B. and N.S. by providing technical advice and stocks for broodstock development. (Farmer, Goff, Aitken)
3. Modify hatchery facilities to improve smolt quality as measured by an index. (Farmer, Jansen, Hubley)
4. Carry out trapping and trucking operations for adult salmon and gaspereau returning to the Mactaquac hydro dam on the Saint John River. (McAskill)
5. Increase public awareness of ongoing DFO programs and the fishery resources of the Scotia-Fundy Region. (Farmer)

#### 6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

#### 7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

All program goals were met or exceeded. Hatchery operations are efficient but risk is high because of ageing equipment and facilities and limited backup. The quality of the hatchery produced smolts is improving with the upgrading of hatchery facilities which is being accomplished largely with non-A-base funds. Expansion of hatchery facilities and programs will be necessary in the near future if the demands for hatchery stocks to support Native fisheries are to be met. The high level of performance from this project depicts the dedication of staff members. Because many staff members are approaching retirement, plans must be made and action taken to recruit capable and highly qualified new fish culturists to the project beginning in 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 309

Section: Fish Culture

Project Title: Fish Culture Research

Project Leader: Farmer, G.

Other Researchers: McAskill, J.; Aitken, D.; Goff, T.; Austin, W.; Penney, G.; Young, E.

Work Activity: W.A.1.1.2.4

Key Words: aquaculture; Atlantic salmon enhancement; hatcheries

1. Project Description:

Devise salmon broodstock, rearing, distribution, marking, evaluation and research programs and coordinate these programs with hatchery staff, stock assessment and enhancement biologists, engineers and fish health and nutrition biologists. Feedback from these programs is used to improve rearing methods, facilities, smolt quality and survival. Private aquaculture proposals are assessed for federal/provincial funding agencies. Chair salmon seedstock committees in Nova Scotia and New Brunswick involved in the coordination of seedstock supply to private-sector hatcheries and marine cage sites and in the implementation and assessment of salmon broodstock development programs. Chair scientific advisory committee to the Salmon Genetics Research Program.

2. Long-Term Objectives:

Provide and coordinate biological input to the Division's hatchery programs to ensure their effectiveness and continued improvement. Liaise with provincial fisheries officials and the aquaculture industries in Nova Scotia and New Brunswick in the areas of salmon seedstock supply, broodstock development and the assessment of private aquaculture proposals. Chair scientific advisory committee to the Salmon Genetics Research Program.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Coordinate and provide biological input to the Region's fish culture program. Improvement in the quality of both 1+ and 2+ smolts is possible and of high priority. (Farmer)

Rearing, broodstock, nutrition, fish health, marking and research programs were devised in conjunction with hatchery managers, Branch biologists, engineers and scientists and then implemented. Sixty-five percent of the 1+ smolts and 85% of the 2+ smolts produced at Scotia-Fundy hatcheries were observed to be of good quality. Research has shown that the necessary improvement in smolt quality will require the replacement and/or modification of outmoded rearing ponds at the Mactaquac, Saint John and Cobeguid hatcheries. Considerable improvements to the ponds at these locations were carried out during 1991. Most of the concrete raceways at the Saint John Hatchery were removed and replaced with eight, deep, 7.6 m Swedish-type ponds. Walls of 11 - 11 m Swedish-type ponds at the Mactaquac Hatchery were extended so that water depth in the ponds could be increased to 1 m. Modifications to the earthen ponds at Cobeguid Hatchery were completed. Ponds at that location were deepened, reshaped and the deteriorating control structures replaced.

2. Work with the salmon aquaculture industries in N.S. and N.B. to develop and assess their broodstock programs. (Farmer, Aitken, Goff)

Thirty thousand Saint John River 1+ smolts were produced at the Saint John Hatchery for the New Brunswick Salmon Growers broodstock development program which is being conducted as part of the Salmon Genetics Research Program. Twenty-two thousand LaHave, River Philip and Saint John 1+ smolts produced at the Mersey Hatchery were supplied to three sea cage operators in Nova Scotia during 1991 as part of an industry broodstock development program. The performance of the smolts supplied to the Nova Scotia industry during 1990 was assessed and the results reported to industry members.

3. Chair the N.B. and N.S. Salmon Seedstock Committees. (Farmer)

Meetings were held and contacts made with industry members in N.S. and N.B. to discuss salmon seedstock supply. Present DFO involvement is primarily to provide seedstock for broodstock development purposes. Smolt supply in the Scotia-Fundy Region from private hatcheries ranges from 3.5-4 million annually and the sea cage industry has generally been self-sufficient in terms of smolt supply. However, an oversupply of smolts in Nova Scotia during 1991 caused hardship for some private hatchery operators who were unable to market their product. In New Brunswick, the destruction of 300,000 smolts at a private hatchery last spring because of disease concerns caused some smolt shortages. DFO was required to supply 50,000 smolts from the Mactaquac Hatchery to help alleviate the shortage. Some recent developments may influence the future supply of private-sector smolts in N.S. and N.B. Revision of the federal Fish Health Protection Regulations may allow the movement of private-sector smolts from N.S. to N.B. and alleviate oversupply problems in N.S. Approximately 200,000 smolts being reared in Maine presently satisfy the Fish Health Protection Regulations for

marketing in N.B. However, smolt demand in N.B. may increase with the end of the provincial moratorium which restricted increases in the number of sea cage sites.

4. Continue as a member of the N.B. Salmon Development Working Group. Identify hatchery proposals submitted for ERDA and/or ACOA funding, which have potential for success. (Farmer)

Participated as a member of the N.B. Salmon Development Working Group formed to evaluate private hatchery proposals submitted for ERDA and/or ACOA funding. Only three proposals for construction of hatcheries in N.B. were submitted for review during 1991. However, nine proposals originating in Nova Scotia and seeking funding (ACOA, ISTC, AFAP, N.S. Research Foundation Corporation) for the development of sea cage sites were reviewed.

5. Report on completed biological investigations. (a) Improvements in salmon egg quality attributable to changes in holding practices. (b) The influence of parentage and smolt size at release on age at maturity of adult Atlantic salmon. (c) Survey of east Shelburne County rivers in preparation for smolt release and liming experiments. (d) Sex ratios of hatchery-reared salmon smolts. (e) Effects of stream liming on invertebrate diversity and abundance. (f) Gull worm incidence among juvenile Atlantic salmon. (Farmer)

Report (c) is nearing completion and another manuscript 'Some factors which influence the survival of hatchery Atlantic salmon smolts (Salmo salar) utilized for enhancement purposes' was presented as part of the Colloque Sur L'Enseignement, March 1-3, 1991, Quebec City and is in press.

6. Chair the Scientific Advisory Committee of the Salmon Genetics Research Program. (Farmer)

The Scientific Advisory Committee (SAC) met October 16 and 17, 1991, with Salmon Genetics Research Program (SGRP) staff to review ongoing programs. A report of the review prepared by the SAC provides an assessment of ongoing SGRP programs and makes recommendations for future research initiatives. The SAC chairman will meet with SGRP staff early in 1992 to discuss recommendations outlined in the review.

7. Reconstruct salmon rearing ponds at the Saint John, Mactaquac and Cobequid hatcheries. (Engineering Services and Fish Culture sections)

Pond reconstruction and modifications at the three hatcheries completed as outlined in 3(1) will result in a significant improvement in smolt quality. An electrical upgrade of the Saint John Hatchery is also nearing completion.

#### 4. Additional Accomplishments:

The Mactaquac Visitor Facility was officially opened during June. Guided tours of the hatchery are provided to the public and feature the viewing of juvenile and adult Atlantic salmon as well as other species of freshwater and anadromous fishes. Displays and written material are available to explain Atlantic salmon biology, salmon enhancement and management programs and fish culture techniques. (Engineering Services and Fish Culture sections)

#### 5. Goals/Expected Outputs for 1992:

1. Coordinate and provide biological input to the Region's fish culture program. Improvement in the quality of both 1+ and 2+ smolts is possible and of high priority. (Farmer)
2. Work with the salmon aquaculture industry in N.S. to develop and assess their broodstock program. (Farmer)
3. Chair the N.B. and N.S. Salmon Seedstock Committees. (Farmer)
4. Identify aquaculture proposals submitted to federal agencies for funding which have potential for success. (Farmer)
5. Report on completed biological investigations. (a) Improvements in salmon egg quality attributable to changes in holding practices. (b) The influence of parentage and smolt size at release on age at maturity of adult Atlantic salmon. (c) Survey of east Shelburne County rivers in preparation for smolt release and liming experiments. (d) Sex ratios of hatchery-reared salmon smolts. (e) Effects of stream liming on invertebrate diversity and abundance. (f) Gull worm incidence among juvenile Atlantic salmon. (g) Magnitude of cormorant predation on salmon smolts. (Farmer)
6. Chair the Scientific Advisory Committee of the Salmon Genetics Research Program. (Farmer)
7. Modify existing 11 m Swedish-type rearing ponds at the Mactaquac Hatchery and construct an additional 8 - 7.6 m Swedish-type ponds at the Saint John Hatchery (Engineering Services and Fish Culture sections).

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

With P.J. Austin - Smith, Nova Scotia Department of Lands and Forests, on the predation of double-crested cormorants, Phalacrocorax auritus on hatchery and wild Atlantic salmon smolts in Nova Scotia rivers.

## ii. University Liaison -

R. Doyle and C. Herbinger (Gene Probe Laboratory, Dalhousie University) are involved in the joint DFO - N.S. aquaculture industry salmon broodstock development program and will advise the industry on broodstock selection practices.

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

Farmer, G.J. 1991. Programs of the region's fish culture stations, p. 48-51. In T.E. Smith (ed.) Science Review 1988 and 89. Scotia-Fundy Region, Department of Fisheries and Oceans, Box 1006, Dartmouth, N.S. B2Y 4A2.

MacPhail, D.K. 1991. Ages of the salmon broodstock collected in the Scotia-Fundy Region during 1990. Internal Document 91-01, 57 p.

McLean, E.J. 1991. Quality evaluation of hatchery-reared 1+ Atlantic salmon smolts. Internal Document 91-04, 124 p.

McLean, E.J. 1991. Quality evaluation of hatchery-reared 2+ Atlantic salmon smolts. Internal Document 91-05, 51 p.

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project provides the biological support and feedback for improving the efficiency of hatchery operations and the effectiveness of hatchery projects. It also coordinates the inputs from other sections and divisions of DFO, other government agencies and the public to the Division's fish culture program. In recent years the effort directed towards the conduct of biological investigations has decreased because of loss of the project leader and responsibility for program direction falling on the Section Head, who is burdened with an exceptionally heavy administrative workload. Effort in 1991 deteriorated further with the retirements in the Section of a senior biological technician and the Supervisor of Hatchery Operations and Production. With these retirements biological output decreased and the administrative workload of the Section Head increased. Because the biological investigations carried out under this project are of the utmost importance to continuing to improve the success of the Division's hatchery program, consideration must be given to reinstatement of the science component of this project. The science output and corresponding improvements in hatchery performance will continue to be modest unless more resources are assigned to address key biological questions.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 310

Section: Stock Assessment and Enhancement

Project Title: Anadromous Species Statistical Consulting and Data Collection and Analysis

Project Leader: O'Neil, S.

Other Researchers: Cutting, R.; Marshall, L.; Harvie, C.; Jessop, B.; Newbould, K.

Work Activity: W.A.1.1.1.1

Key Words: data processing; salmon; assessments; biostatistics

1. Project Description:

Provision of timely and accurate catch/effort statistics (both commercial and sport) for diadromous fish species to scientific staff, fishery managers, provincial resource agencies, and the public. Responsibility for the collection of diadromous statistics was delegated to the Freshwater and Anadromous Division, and procedures for salmon are coordinated with some provincial resource agencies. Preliminary analyses are carried out on data, and the systems developed are verified for accuracy and timeliness. The Tag Clearing House is administered by this project, supplying biologists and scientists with a computerized system for entry and retrieval of release and recapture data on wild and hatchery stocks of Atlantic salmon. Biostatistical consulting services are also provided under this project.

2. Long-Term Objectives:

(i) To provide catch/effort statistics for the diadromous fish species in the Region as required by DFO. (ii) To maintain an information retrieval system for Division tagging and tag recapture data. (iii) To provide editing services to the Division; and (iv) To provide biostatistical consulting services to Division members.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Ensure that catch and effort data for anadromous sport and commercial fisheries are provided in a timely and accurate fashion for stock assessment purposes, for planning and assessment of enhancement projects, and for habitat management. (O'Neil, Harvie)

Data on various species were collected, analyzed and summarized for distribution to assessment staff and other resource agencies as required. (i.e., CAFSAC, Research Branch, Ottawa, Regional FHM Branch, NASCO, ICES, Nova Scotia Department of Natural Resources).

2. Maintain Tag Clearing House for: (a) Regional salmon tagging programs; and (b) Canadian salmon tagging programs. (Newbould, O'Neil)

Maintained and summarized as required by clients.

3. Provide editorial services to Division staff. (Newbould)

Five manuscripts were edited and sent out for publication.

4. Continue to provide base statistics for users by conducting the following priority projects:  
(a) 1989 and 1990 sportcatches to be published for wider distribution; (b) creel surveys to be designed as required and data analyzed as priorities and schedules permit; (c) improved documentation of existing recreational data base; (d) publication of a report on proposed New Brunswick salmon fishery data collection methods. (O'Neil, Cutting, Marshall)

(a) Data distributed; manuscripts are in preparation. (b) Creel surveys were designed for the Kennebecasis and Saint John rivers. The resulting data were analyzed and the results were relayed to the relevant biologist-in-charge. (c) Documentation of the existing recreational data base has been improved but is not completed. (d) Draft report has been prepared. Additions to the results and discussion are necessary prior to circulation for review.

5. Develop a creel survey design for the St. Mary's River 1991 fishery. (O'Neil, Jessop)

This goal was anticipated but early indications of a need for this were apparently incorrect. No formal request for a creel survey for the Saint Mary's River was made.

4. Additional Accomplishments:

Staffed CS position with C. Harvie, who has a strong mathematics background. Provided biostatistical advice and consulting to division staff for almost the entire reporting period.

Made progress on a report to document historical salmon angling seasons, catch, effort and discharge.

5. Goals/Expected Outputs for 1992:

1. Ensure that catch and effort data for anadromous sport and commercial fisheries are provided in a timely and accurate fashion for stock assessment purposes, for planning and assessment of enhancement projects, and for habitat management. (O'Neil, Harvie)
2. Maintain Tag Clearing House for: (a) Regional salmon tagging programs; and (b) Canadian salmon tagging programs. (Newbould, O'Neil)
3. Provide editorial services to Division staff. (Newbould)
4. Design creel surveys and analyze the resulting data, as required. (O'Neil)
5. Prepare documentation of catch/effort system. (O'Neil)
6. Provide required biostatistical consulting. (Harvie)
7. Complete publication of 1989 and 1990 angling statistics in Data Report Series and work towards finalizing seasons/discharge report. (O'Neil)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

O'Neil, S.F. and D.A.B. Swetnam. 1991. Collation of Atlantic salmon sport catch statistics, Maritime Provinces, 1951-59. Can. Data Rep. Fish. Aquat. Sci. No. 860.

O'Neil, S.F., D.A. Stewart, K. Newbould and R. Pickard. 1991. 1988 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rep. Fish. Aquat. Sci. No. 852.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Good progress was made on all goals with the exception of goal 5 which was not required. The Division's capabilities in biostatistics were greatly enhanced with the staffing of the Unit's CS position with C. Harvie.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 311

Section: Stock Assessment and Enhancement

Project Title: Divisional Informatics

Project Leader: O'Neil, S.

Other Researchers: Amiro, P.; Cutting, R.; Harvie, C.; Marshall, L.; Boudreau, P.R.

Work Activity: W.A.1.1.1.1

Key Words: administration; data processing; informatics

1. Project Description:

Directs Freshwater and Anadromous Divisional informatics programs including planning and review, the development of software, software evaluation, hardware acquisition and maintenance, staff training or coordination of EDP related training and data base management system development. Provides advice to Division staff on software, hardware and program-related EDP requirements.

2. Long-Term Objectives:

Continue to provide software development and maintenance service, and system management expertise. Upgrade the level of competence of Division staff on in-house micro-computer and mainframe systems (software and hardware). Ensure that Division EDP requirements are addressed and provided, wherever possible, and work towards having Division staff make more effective use of the data on hand and to prepare for efficient use of any new data being collected.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Fill vacant computer services coordinator position. (O'Neil, Cutting)

CS position filled on acting basis, January 21, 1991; filled permanently in early May 1991.

2. Orient and train new CS in existing programs and objectives, particularly the ORACLE data base systems. (O'Neil)

The CS was familiarized with ongoing programs and initiatives. The practical aspects of ORACLE data base development was delegated to a term CS. The staff CS was trained for one week in ORACLE.

3. Finalize conversion of all HP1000-based software and IMAGE/QUERY data bases to micro-computer systems. (CS)

All IMAGE/QUERY dbase has been transferred to IBM-PC based systems. The distribution data base has been completed (in ORACLE), the Tag Clearing House data base is 65 percent complete and the trap data base will be completed in 1992.

4. Establish image processing station for use in discriminant function analyses and related applications. Become familiar with the BIOSCAN-OPTIMUS software and provide consulting support on same. (Amiro, O'Neil, CS)

An image processing station was set up and Windows 3.0 and BIOSCAN-OPTIMUS software installed and tested. Consulting support on the system was provided as required.

5. Initiate adult salmon trap data base development with plans to complete same in 1992. (CS, Marshall, Cutting)

The trap data base (see 3 above) was initiated and will be completed in 1992. The trap data base may become incorporated into a larger scale data base system development plan.

6. Participate in GIS acquisition and installation/development. (CS)

A GIS (SPANS) was acquired by the Habitat Research Section. The system was not installed during 1991. Use of a GIS has been confined to Habitat Research Section during this reporting period.

7. Provide long-range EDP planning support by keeping abreast of changes in technology. (O'Neil)

A long range EDP plan was prepared to cover the years 1991-95. The plan has served the Division well in that a diversified group of IBM-PC's have met our computing needs during the past two years.

8. Collaborate in developing solutions in enhancement or assessment related problems by applying EDP science and technology. (CS)

Quattro-pro was selected as an optimal tool for preliminary analysis and graphical display of trap

data. A Saint John River salmon returns model was tested in SYSTAT re: non-parametric and parametric models. Prepared a network proposal to facilitate analysis of the angling data set.

9. Provide consultative computing support and training to division staff, as required. (CS)

Consultative support was provided as required. A course in MS-DOS was prepared and taught to 16 staff. A course in LOTUS-1-2-3 was taught to six staff members.

4. Additional Accomplishments:

Worked with Frank Curry, Informatics and Systems Services Division, to coordinate installation of BANYAN VINES network to FWA, including wiring, installation of ethernet cards, a controller and server access for peripherals.

5. Goals/Expected Outputs for 1992:

1. Conduct comprehensive review of data base management requirements for the Division, evaluate options and recommend course of action. A tentative plan to prepare a large scale DBMS with links to statistical and graphical software will be carefully considered during the review because of the significant costs involved. (O'Neil, Harvie, Marshall, Cutting)
2. Complete (pending the outcome of 1) development of the trap data base system. (O'Neil, Harvie, Marshall)
3. Provide informatics consulting support, including software development and training to Division staff. (Harvie, O'Neil)
4. Prepare a long range informatics plan which reflects anticipated informatics need and the changes in technology. (O'Neil, Harvie)
5. Complete evaluation of a network proposal for in-house (LAN) and, if approved, install, test and support. (Harvie)
6. Evaluate feasibility of use of GIS for graphical display of geobased data or modelling. (Harvie, Boudreau, O'Neil)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

Memoranda to division management providing advice and options.

Bullerwell, A., E.J. MacLean, D. Wallace and C. Harvie. 1991. Documentation of the hatchery fish distribution ORACLE data base. In-house report.

8. Review and Evaluation:

With the filling of the Division's lone CS position this project is once again on track. The major challenges for 1992 are to decide upon the most appropriate DBMS and to establish the blueprint for its application throughout the Division.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 315

Section: Freshwater Habitat Research

Project Title: Acid Rain Research

Project Leader: Watt, W.

Other Researchers: White, W.; Watson, N.; Ritter, J.

Work Activity: W.A.1.1.3.2

Key Words: acid rain; Atlantic salmon; computer model; mitigation; liming; biomonitoring

1. Project Description:

Chemical and biological monitoring of river and lake acidification and its impact on Atlantic salmon and other freshwater species. Investigation of possible mitigation techniques, pilot studies, and demonstration projects (liming). Model development to assess the impact of acid deposition on salmon production.

2. Long-Term Objectives:

Long-term objectives are to: (1) provide information to aid policy development under international air quality agreements, and under NASCO and ICES; (2) design and test mitigation procedures and apply them to preserve (for a future restocking effort) nuclei of Atlantic salmon stocks presently threatened with extinction; (3) maintain a long-term biomonitoring program to detect biological changes attributable to increases or decreases in acid deposition, and to determine the impact of acidification/deacidification on selected freshwater communities.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue long-term biomonitoring protocols for limno, littoral and river benthos, lake and river fish, and acid river bioassays with caged juvenile Atlantic salmon. (Watson, White, Barbour, Watt)

All biomonitoring protocols were completed in 1991, the fourth year of the biomonitoring program. Macroinvertebrates samples were collected three times (spring, summer and fall) at five river sites and twice (spring and fall) at three lake sites (Watson). Counting and identification of the 1990 samples is proceeding (contract) and will be completed before the end of the year. Fish samples were collected from three lakes (White). Fish bioassay cages were deployed at four river sites in 1991. (White, Barbour, Watt)

2. Continue monthly water sampling and annual electrofishing in eight acidified Nova Scotian rivers to monitor the fate of remnant Atlantic salmon populations. Prepare a report on results from the first ten years. (White, Watt)

Monthly water sampling and chemical analyses were carried out on all biomonitoring rivers (Watt). Annual electrofishing was carried out on eight of Nova Scotia's acidified rivers to assess the present status of acid-impacted remnant salmon stocks and other fish species in these rivers (White). This was the eleventh year of the N.S. salmon river biomonitoring project. An interim report on the design and the preliminary results is in preparation, but because of changes in national priorities the report has been postponed to allow for a proposed downsizing and reorganization of this long-term project.

3. Continue liming and biological/chemical monitoring of the demonstration deacidified refuge in the East Branch of East River, N.S. (White, Watt)

In Jan-Feb of 1991, 400 tonnes of powdered limestone were spread over the ice of four headwater lakes of the East Branch of East River, Nova Scotia. This was the sixth consecutive year of liming. The deacidified refuge and its controls are biologically and chemically monitored. Refuge pH's remained stable at near neutrality (Watt). Salmon parr and fry numbers increased further at all stations within the limed portion of the river, indicating colonization of empty deacidified habitat by the enhanced numbers of returning spawners (White). Main river sites (below the confluence with the limed tributary) have also been successfully colonized (White), and water chemistry shows significant down-river improvement (Watt). This implies a substantial export of acid neutralizing capacity from the refuge, indicating that the system is now near saturation. The extent of annual liming can now be reduced, since the original concept was that only a small refuge would be required to maintain the genetic continuity of the stock (Watt). A report is in preparation (Watt).

4. Test the preliminary freshwater and marine life stage modules of the acid river Atlantic salmon model, correct shortcomings and prepare final versions. Program and commence testing the preliminary hydrochemical module. (All Habitat Research staff plus other Sections and Divisions of Biological Sciences Branch)

Marine and freshwater modules were programmed and tested, and a number of shortcomings were noted. A contract has been let (with Environmental and Social Systems Analyst Ltd. of Vancouver) to prepare revised versions, and to prepare a hydrological and geochemical module to complete the model (Watt, and staff from other Sections and Divisions of Biological Sciences Branch, and from Environment Canada).

5. Assess the results of the 1990/91 study. Do a mobility (microscopy) and/or viability (fluorescent) study of cryopreserved sperm (precocious parr) from Atlantic coast stocks, to test for compatibility with cryopreservation methodology. (Watt)

Aquaculture funds were not available, so the planned joint project could not proceed. The available funding (AFAP) was used to support one student's research for one year. Sperm was collected from 230 precocious salmon parr, and cryogenically preserved. Thawed sperm was tested for motility and damage (fluorometry). These results will be compared with results from fertility tests conducted this fall with thawed sperm and fresh eggs. A thesis is expected (Guelph) in 1993 (Watt).

#### 4. Additional Accomplishments:

Analysis has been completed on a study examining twenty years of presence/absence data on N.S. lake fish species, and the relation between disappearance of species and levels of acidity. A report is in preparation. (White)

A national benthic invertebrate species list was developed for the biomonitoring data base, and the list has been computerized. (Watson)

#### 5. Goals/Expected Outputs for 1992:

1. Continue long-term biomonitoring protocols for lake benthos and fish, scaling down the benthos portion to one sample per year. (Watson, White)
2. Reorganize the acid river biomonitoring program (chemistry, invertebrates and fish), reducing the scale and the number of rivers, and mothballing the caged fish bioassay program. (White, Watt)
3. Commence computerization and transmission of the biomonitoring data to the national data base. (White, Watson, Watt)
4. Maintain the limed refuge on East River, N.S. as a study area to measure the juvenile salmon production levels that can be achieved by deacidifying an Atlantic Upland stream. This information is required for development of the computer simulation model of salmon in acid rivers, see #5 below. (White, Watt and staff of Stock Assessment Section)
5. Test the preliminary hydrochemistry module of the Atlantic Salmon Regional Acidification Model, identify shortcomings and prepare a revised version. Test the revised versions of the freshwater and marine life stage modules and design studies to collect some of the data required to fill the information gaps made apparent by the modelling exercise. Program and commence testing the preliminary hydrochemical module. (All Habitat Research staff plus staff from other Sections and Divisions of Biological Sciences Branch and Environment Canada)
6. Complete data analysis and publish:
  - (i) Creation of a limed refuge for genetic preservation of an Atlantic salmon stock threatened by acidification, East River, N.S. (Watt)
  - (ii) Evidence for lethal and sub-lethal effects of acidification, and their mitigation, in semi-natural caged fish bioassays using juvenile Atlantic salmon. (Watt)
  - (iii) Model of Atlantic salmon production in relation to stream pH. (Ritter, Regional DFO staff and ESSA)

#### 6. Background:

##### Highlights:

A regional tax (\$20,000) on our LRTAP funding means that processing of 1991 benthic samples will be delayed, and regional biomonitoring data from previous years cannot be computerized and transmitted to the new national data base (\$10,000 was given to us for regional data base development this year).

##### Selected Involvements:

##### i. Collaborative Research -

Dr. R. K. Misra (Physical and Chemical Sciences Branch) is developing specialized statistical procedures and computer programs for trend-through-time analysis of the biomonitoring data.

The Environment Canada Water Quality Laboratory in Moncton, N.B. performs major ion and metal analyses on stored water samples from the biomonitoring program.

##### ii. University Liaison -

Dr. David Cone, St. Mary's University, Halifax, N.S. is collaborating on a study of eel parasites as indicators of acidification in N.S. rivers. A manuscript is in preparation.

##### iii. Communications -

## iv. Contracts Administered -

Mr. Paul Mandell, Halifax, N.S. - same day analyses for water chemistry parameters that do not permit storage (\$20K).

Environmental and Social Systems Analysts Ltd, Vancouver, B.C. - Development of models to assess the impacts of acid deposition on Atlantic salmon production in Nova Scotia (\$76K).

Ms. Lynn Barrington, Halifax, N.S. - Caged fish bioassays in acid rivers (\$12K).

Dr. K.A. Neil, Acadia University, N.S. - Identification and enumeration of benthic invertebrates (\$10K).

## v. Other -

The biomonitoring program requires considerable person-power, supplied this year by five students.

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project will undergo major changes in 1992. Both the lake and stream biomonitoring activities are being streamlined to match the lower level of funding anticipated in the future. Similarly, the caged fish bioassays will be discontinued. The lake liming activity will move into a new phase with achievement of the initial objectives, and the modelling exercise will be greatly reduced with completion this year of the second of the two major phases of this activity. 1992 should see the emergence of a streamlined project and increased effort on preparation and analyses of data and publication.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Freshwater and Anadromous

Project No.: 316

Section: Freshwater Habitat Research

Project Title: Freshwater Fish Habitat Assessment and Related Research

Project Leader: Watt, W.

Other Researchers: White, W.; Boudreau, P.R.

Work Activity: W.A.1.1.3.1

Key Words: alewife; Atlantic salmon; habitat research; mitigation; gaspereau; salmon enhancement

1. Project Description:

Conduct biological investigations as required to protect freshwater fisheries habitat by: (a) reviewing all major development proposals and doing field assessments to determine the potential for impact on freshwater and anadromous fisheries; (b) conducting post-construction assessments of mitigation effectiveness and developing improved mitigation techniques; and (c) investigating habitat problems relating to fish passage, habitat alterations, water diversions, and screening of intakes.

2. Long-Term Objectives:

Provide DFO's freshwater research and assessment requirements arising from the fish passage and habitat protection sections of the Fisheries Act, and the Federal Environmental Assessment and Review Policy (EARP).

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Respond to any freshwater fish habitat related EARP and RSCC environmental impact assessment referrals, and prepare Initial Environmental Assessments and (where necessary) Initial Environmental Evaluations for new projects in the Freshwater and Anadromous Division. (White)

Environmental assessment activity: An Environmental Impact Assessment Report was prepared for a DFO project to provide fish passage on the upper Saint John River at Grand Falls N.B. An Environmental Impact Assessment was reviewed for a hydroelectric project at Morgan Falls N.S. on the LaHave River. Initial Environmental Assessments were prepared for enhancement and fish passage engineering at Grand River, N.S.; St. George, N.B.; Sheet Harbour, N.S.; and Morrison Brook, N.S.; replacement of underground fuel storage tanks at all hatchery sites; outdoor pond construction and modification at Saint John, Mactaquac and Cobequid, and dam repairs at Yarmouth; lake liming and road repairs at East River, N.S.

2. Design, and if flow conditions permit, carry out an assessment of the effectiveness of the downstream bypass at Milltown, St. Croix River, New Brunswick/Maine. The study will use radio tagged Atlantic salmon smolts. (White, Watt)

The experimental design is complete and all necessary equipment is ready, however, flow conditions were not suitable in 1991. Spillage of excess water over the dam took place during most of this year's smolt migration. The effectiveness of the bypass cannot be tested when excessive amounts of water are being spilled.

3. Provide scientific advice to the Fisheries and Habitat Management Branch and senior DFO management with regard to non-guidelined and complex fish habitat alteration proposals, and other technical problems affecting the administration of the fish passage and fish habitat protection sections of the Fisheries Act. (White, Barbour, Watt)

A field reconnaissance was conducted on the Madawaska River (N.B.), and local user groups were consulted. Consultant proposals were reviewed and advice was provided for letting a contract to conduct a survey of the fishery enhancement potential of the river.

Advice was provided on the resource requirements for liming proposals on the Barrington River (Shelburne Co.), Meteghan River (Yarmouth Co.), Salmon and Bear rivers (Digby Co.), Little Salmon River (Halifax Co.), the 101 Highway at Little Springfield Lake (Halifax Co.), a liming and flow diversion proposal for Jordan Lake (Shelburne/Queens Co.), and a proposed stream liming program on Cape Breton Island.

Advice was provided re effects of water quality on salmon and trout populations in MacKintosh Run (Halifax Co.), on the regulation of water levels in the St. Croix River to protect anadromous fish habitat, on the suitability of urban lakes for trout stocking and/or natural populations, and fishery resources in the vicinity of all existing military bases in Scotia Fundy.

Fish kills were investigated on Nine Mile River at Enfield (July 11) and Fall River (July 22).

4. Monitor for possible reappearance of the Coho salmon incursion on the Cornwallis River, as per ICES recommendation. (Barbour)

Not done. All discretionary summer field programs were cancelled due to lack of funds.

5. Carry out a statistical analysis of the data on microhabitat availability (IFIM), egg deposition and electrofishing densities of juvenile salmon in the Tobique River system, N.B., and prepare a report. (Boudreau)

The analysis has been completed and a draft manuscript prepared.

6. If GIS resources are available, investigate the practicality of integrating the LaHave River salmon management model with a GIS. (Watt, Boudreau)

Programs were written to convert NTX format to ESL format, and digital base maps for the entire LaHave drainage have been converted for use with INFOCUS/QUIKMAP and SPANS. An attempt to install an old version of SPANS was only partially successful, however, several model conversion problems have been resolved. Based on this experience a new version of SPANS was acquired, for running in OS-2 instead of MS-DOS.

7. If resources are available, commence data assessment and computerization for the detection of impacts of long-term climate changes on freshwater habitat in Scotia-Fundy. (Watt, Boudreau)

No resources were available to do this work.

8. If equipment and resources are available, install and do preliminary tests on an acoustic array system for the automated counting of migrating salmon (adult and juvenile). Progress in habitat research is presently handicapped by lack of an accurate (and non-person-power intensive) method to measure habitat productivity. An automated method for smolt (and adult) counting that could be installed on virtually any river would be invaluable. (Boudreau)

No resources were available to do this work.

#### 4. Additional Accomplishments:

Our new biologist (Boudreau) successfully completed a course in limnology at Dalhousie University, to broaden his knowledge of freshwater systems.

#### 5. Goals/Expected Outputs for 1992:

1. Respond to any freshwater fish habitat related EARP and RSCC environmental impact assessment referrals, and prepare Initial Environmental Assessments and (where necessary) Initial Environmental Evaluations for new projects in the Freshwater and Anadromous Division. (White)
2. Design, and if flow conditions permit, carry out an assessment of the effectiveness of the downstream bypass at Milltown, St. Croix River, New Brunswick/Maine. The study will use radio tagged Atlantic salmon smolts. (White)
3. Provide scientific advice to the Fisheries and Habitat Management Branch and senior DFO management with regard to non-guidelined and complex fish habitat alteration proposals, and other technical problems affecting the administration of the fish passage and fish habitat protection sections of the Fisheries Act. (White, Watt)
4. Set up a SPANS GIS model of juvenile salmon production in the portion of LaHave river above Morgan Falls. (Boudreau)
5. Publish a Technical Report on relative roles of egg deposition and habitat availability in juvenile salmon densities in Gulquac River, Saint John System, N.B. (Watt).
6. Publish a Technical Report on relation between alewife run density and efficiency in use of a fish ladder on the St. Croix River, N.B. (Watt)

#### 6. Background:

##### Highlights:

Finally getting the 1983 data set on Gulquac analyzed. This was made possible by assignment of an additional biologist to the Habitat Research Section.

##### Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

Barbour, S.E. Atlantic salmon habitat evaluation in the context of the Department of Fisheries and Oceans (DFO) policy for the management of fish habitat. p. 9-12, in "Collected papers on fish habitat with emphasis on salmonids", CAFSAC Research Document 90/77 (423 p.).

Barbour, S.E. Microhabitat selection by juvenile Atlantic salmon in a small, unstable stream; p. 295-306, in "Collected papers on fish habitat with emphasis on salmonids", CAFSAC Research Document 90/77 (423 p.).

White, W.J. Limitations of Habitat Evaluation Procedure (H.E.P.) models for fish habitat management; p. 237-254, in "Collected papers on fish habitat with emphasis on salmonids", CAFSAC Research Document 90/77 (423 p.).

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Scarcity of resources (O&M and technical support) prevent the undertaking of new field research initiatives. Hence, 1992/93 will be largely confined to service (rather than research) and the publication of past research results.

**AQUACULTURE AND INVERTEBRATE FISHERIES DIVISION**

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 400

Section:

Project Title: Coordination, Aquaculture and Invertebrate Fisheries Program

Project Leader: Cook, R.

Other Researchers: Chang, B.; Fawkes, G.

Work Activity: W.A.1.1.1.3; W.A.1.1.2.2; W.A.1.1.3.2

Key Words: aquaculture; invertebrate fisheries; habitat ecology

1. Project Description:

The Aquaculture and Invertebrate Fisheries Division has lead responsibility for finfish culture in the marine environment, experimental marine fish larval work, and the culture of invertebrates applicable to the Bay of Fundy area. Specific responsibilities include the management of research programs on physiology of salmonid growth and reproduction, invertebrate biology and aquaculture, marine finfish aquaculture, aquaculture ecology research, marine phytotoxins, groundfish ecophysiology, salmon ecology and acid rain. The Division also has the lead responsibility for invertebrate fisheries assessments and biological research in the Bay of Fundy area. Other specific responsibilities within the Biological Sciences Branch include: focus for Aquaculture Research and Development in Southwestern New Brunswick; administration of St. Andrews Biological Station as a Regional Science Institute.

2. Long-Term Objectives:

Plan, direct and coordinate research programs in fields of aquaculture research and development relevant to the responsibilities of the Biological Station for aquaculture and invertebrate fisheries research; facilitate technology transfer related to aquaculture development, particularly marine finfish culture in the Region; manage a federal scientific institution and provide facilities and services necessary to support fisheries research relevant to the overall mandate of the Biological Station; serve as Senior Branch Advisor on aquaculture activities within the Scotia-Fundy Region; assess the invertebrate fisheries resources of the Bay of Fundy area, carry out related research and provide biological advice to fisheries managers.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Direct the scientific research programs on finfish aquaculture, aquaculture ecology and marine toxins, acid rain ecology, and invertebrate aquaculture and fisheries in the Bay of Fundy area. (Cook)

Developed research projects on aquaculture in conjunction with HMSC, ASF (SGRP), the NBSGA, and private sector. Participated in Federal-New Brunswick Environmental Committee for Aquaculture in the Bay of Fundy. Participated in planning of marine toxin research studies and regional LRTAP research through Branch coordinative committees.

2. Promote technology transfer in the field of mariculture and provide a focus for aquaculture development and respond to requests for advice on aquaculture. (Cook, Chang)

Delivered presentations to a broad spectrum of audiences on aquaculture, including industry and scientific associations. Served on Atlantic Aquaculture Fair Executive Committee. Provided advice to Area Manager (SWNB) and to the province on aquaculture and related technology, and to industry representatives and growers. Development of ASDDF project proposals and funding alternatives. Served on Management Committee of ASDDF. Convened technology transfer sessions on aquaculture. Served on Steering Committee on Disease Prevention in N.B. Farmed Salmon Industry (UNB coordinated program).

3. Serve as Senior Branch Advisor on aquaculture. (Cook)

Provided overview on aquaculture programs within Region to senior managers, provided commentary, and represented Region at meetings on aquaculture development. Served on the Coordinating Committee of the Canada-New Brunswick MOU on Aquaculture and related subcommittees. Coordinated responses on behalf of BSB on finfish aquaculture. Served on APICS Aquaculture Committee. Provided advice to ACOA, Fisheries Development Branch, and Canada-New Brunswick Cooperation Agreement on aquaculture development. Participated in working group with Area Manager (SWNB) to coordinate DFO aquaculture activities in Scotia-Fundy section of New Brunswick. Prepared Canadian administrative report to ICES Mariculture Committee and served as rapporteur to Mariculture Committee at the Statutory Meeting.

4. Provide support to the Division's computing needs, including programming and equipment trouble-shooting. (Fawkes)

Support for Division programming and equipment trouble-shooting was provided including: plotting of

scallop and lobster tag recovery data, plotting of scallop surveys, continued development of aquaculture data base. Participated in the Biological Station Computer Advisory Committee. Maintained an inventory of Division computer hardware and software.

5. Serve as Station Director to coordinate provision of scientific support services to all programs and to encourage inter-divisional and Branch research activities carried out at St. Andrews.  
(Cook)

Provided general direction to Coordinator, Station Support Services on the facilities, vessels and other scientific support services at St. Andrews for all scientific research programs. Served as Scientific Authority for Atlantic Reference Centre and as a voting member of the Huntsman Marine Science Centre. Chaired Station Management Committee and represented Station on Regional Science "Tuesday Club". Responded to broad spectrum of general inquiries to St. Andrews Station on fisheries sciences and aquaculture. Provided guidance to Station Communications initiatives. Encouraged inter-Branch/Division participation in work plan development, seminar presentations, and provided guidance to completion of Station Conference Centre and made arrangements for official opening.

6. Coordinate scientific evaluation of aquaculture site applications and develop a geographic data base system for aquaculture developments in the Bay of Fundy area. (Chang)

Coordinated DFO Science input into aquaculture site referral system. Participated as member of Canada-New Brunswick Aquaculture Advisory Committee, Aquaculture Environmental Coordinating Committee, and the DFO Southwestern N.B. Aquaculture Working Group. Development of a geographic data base system proceeded slowly, due to shortage of funds and unavailability of digitized maps for the southwestern N.B. area.

#### 4. Additional Accomplishments:

1. Provided advice and reports to the IJC St. Croix Pollution Advisory Board as a Canadian member in support of the restoration of anadromous fisheries to the St. Croix River.
2. Initiated a number of local facility improvements including the new building for the Atlantic Reference Centre, the Station Conference Centre and Histology Laboratory.
3. Served as Editorial Board of the journal Fisheries Research.
4. Development of plans for Regional Aquaculture Coordination Office.

#### 5. Goals/Expected Outputs for 1992:

1. Manage the scientific research programs carried out at the St. Andrews Biological Station on aquaculture, marine fish and invertebrate fisheries, habitat ecology and marine chemistry in the Bay of Fundy/Gulf of Maine area.
2. Serve as Station Director and coordinate, by means of a Station Management Committee, the provision of scientific and administrative support services to all programs at the St. Andrews Biological Station.
3. Coordinate the evaluation of aquaculture site applications in SWNB and provide a scientific focus for aquaculture development and activities arising from the St. Andrews research programs.  
(Chang)
4. Provide support to the computing needs of the aquaculture, invertebrate fisheries and habitat ecology research projects at the Biological Station. (Fawkes)

#### 6. Background:

##### Highlights:

The project is to provide scientific leadership to the aquaculture, marine fish, invertebrate fisheries and habitat ecology research programs carried out at the St. Andrews Biological Station, Scotia-Fundy Region.

##### Selected Involvements:

##### i. Collaborative Research -

Collaborative research activities are very broad and will be documented within the individual project reports submitted by scientific staff operating out of the Biological Station.

##### ii. University Liaison -

Act as supervisor for Science Subvention projects undertaken by university researchers. Served on regional fisheries and aquaculture committees. Served as a voting member of the Huntsman Marine Science Centre which includes the participation of twelve universities. Encourage staff participation as adjunct professors and supervise postgraduate students.

##### iii. Communications -

Provide numerous interviews and presentations to aquaculturists, fishermen, associations, universities and the press. Wrote several articles for Atlantic Fish Farmer and other regional papers. Served as member of the Atlantic Aquaculture Fair Executive Committee. Ongoing collaboration with communications officer at St. Andrews. Development of display depicting the scientific institutions of St. Andrews.

##### iv. Contracts Administered -

Salmon Genetics Research Program, Atlantic Salmon Federation, \$220K (1990-91). (DFO share, see project 401 for details).

Atlantic Reference Centre, Huntsman Marine Science Centre, \$85K (1990-91) (Core funding base; see Project 540 for details).

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

Cook, R.H. (ed.). 1991. Canada, 4-19. In H. Ackfors (ed.). Activity report 1990/91 Mariculture Committee. ICES C.M. 1991/F:1.

Cook, R.H. and R.E. Lavoie. 1991. Science and aquaculture: a matter of demand and supply, p. 40-44. In Science Review of the Bedford Institute of Oceanography, the Halifax Fisheries Research Laboratory, and the St. Andrews Biological Station 1988 and '89. DFO Scotia-Fundy Region.

Cook, R.H. and W. Pennell (Editors). 1991. Proceedings of the special session on salmonid aquaculture, World Aquaculture Society, February 16, 1989, Los Angeles, U.S.A. Can. Tech. Rep. Fish. Aquat. Sci. 1831: p. 167.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Substantial progress has been achieved in the scientific programs of the Division during the review period. Good progress was achieved with New Brunswick officials and the SWNB Area Manager in aquaculture development and in related communications with the general public. More effective working relationships among the various scientific programs at St. Andrews have been achieved and a number of significant improvements to Station facilities during the review period have been implemented.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 401

Section:

Project Title: Salmon Genetics Research Program

Project Leader: Cook, R.

Other Researchers: Saunders, R.; Ritter, J.; Farmer, G.; Peterson, R.; Olivier, G.; Claytor, R.

Work Activity: W.A.1.1.2.2

Key Words: salmon; aquaculture; salmonid culture; genetics

1. Project Description:

This is a cooperative project of the Department of Fisheries and Oceans and the Atlantic Salmon Federation. It is carried out at the Atlantic Salmon Research Centre near St. Andrews. Initiated in 1973, the research program is designed to advance technology in salmon genetics and demonstrate the benefits of selection which will contribute to the economic value of Atlantic salmon. Research involves the estimation of genetic parameters that will enhance the efficient development of strains of salmon suitable for both the strategies of salmon enhancement and sea-cage culture.

2. Long-Term Objectives:

Design, develop and test models, protocols and procedures for breeding which have practical application both in the management of Atlantic salmon stocks and in aquaculture; chair the Salmon Genetics Research Program Steering Committee to coordinate the development of improved strains of Atlantic salmon so that the strategies of salmon enhancement and cage rearing can be realized; implement the four line selection matrix producing smolt, individually identified as to pedigree, for sea ranching and sea-cage culture; encourage collaborative research at the Salmon Research Centre's facilities to complement the breeding program.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Evaluate freshwater growth and smoltification in control and select lines of the Biotechnology strain.

Two percent increase in smoltification of select vs control line.

2. Spawn control and select lines of Strain 87JC at ASDDF.

Control and select lines spawned in November, 1991.

3. Monitor performance of Strain 84JC with multiplier growers.

Advantages in selects over commercials is apparent in growth corrected for smolt size.

4. Establish families at the freshwater stage in Strain 90JC.

Families are being reared for presumptive smoltification evaluation in early 1992.

5. Evaluate the return rates of control and vaccinated (vibrio and furunculosis) groups of released smolts.

Vaccination was detrimental to return rate.

6. Establish cooperative research projects in sperm cryogenics, disease resistance and evaluation of the behavior of cage escapees, where funds can be obtained.

Progress with University of Guelph on sperm cryogenics with UNB-lead disease prevention project on bacterial kidney disease. Allozyme research on cage-cultured strains by visiting scientist, Dr. T. Cross, Dublin, Ireland, forms a baseline for cage-escapee work.

4. Additional Accomplishments:

1. Monitoring of the performance of SGRP stock multiplier growers.
2. Input to Northeast Division of the Society of Fisheries meetings.
3. Input to the 4th International Symposium of Genetics in Aquaculture, Wuhan, China.
4. Publication of primary, scientific, technical and popular press releases of information.

5. Discussions with individuals and presentations to groups concerned with the genetics of both wild and aquaculture stocks.

5. Goals/Expected Outputs for 1992:

1. Evaluate seawater performance in control and select lines of the Biotechnology strain.
2. Evaluate freshwater performance of control and select lines of the 87JC strain.
3. Integrate disease resistance into the selection index to be used in the 84JC strain.
4. Evaluate smoltification in strain 90JC.
5. Evaluate the return rates of control and vaccinated (vibrio and furunculosis) groups of released smolts.
6. Establish cooperative research projects in sperm cryogenics, disease resistance, allozyme and DNA markers, sea lice resistance and evaluation of the behavior of cage escapees, where funds can be obtained.

6. Background:

Highlights:

The SGRP continued to conduct research and development in the genetics of strains involved in release-return, as well as cage-cultured stocks. The procurement of gametes from the Saint John River for the 89JC and 90JC stocks has involved close cooperation between the ASF and the Freshwater and Anadromous Division (BSB).

Selected Involvements:

i. Collaborative Research -

Assessment of ovarian development in grilse, salmon and grilse x salmon crosses in collaboration with R.R. Claytor, DFO, Moncton.

G. Oliver will be summarizing results on resistance of families to challenges with furunculosis in line with data layout formats recently discussed.

ii. University Liaison -

G.W. Friars is an Honorary Research Associate of the University of New Brunswick, where he acts as co-supervisor of a Ph.D. student, Alex Hanke.

G.W. Friars has been appointed to the supervisory committee of Adam Harrington, a graduate student at the University of Guelph, doing cooperative research with the SGRP on sperm cryogenics.

Preliminary work on the role of methyl testosterone on the reconditioning of kelts has been commenced with L.W. Crim of Memorial University. Further studies will be developed in connection with successes encountered in 1991.

Pedigreed families have been reared for DNA fingerprinting research in conjunction with C.M. Herbinger and R.W. Doyle, of Dalhousie University. Additionally, blood samples have been procured to evaluate DNA heterozygosity in released smolts contrasted to returning adults.

Modelling of parr length distribution is being conducted in conjunction with I. McMillan and M. Quinton, of the University of Guelph.

Collaborative work on milt cryogenics is being planned with R. Moccia, of the University of Guelph and M.A. McNiven, of the Atlantic Veterinary College. A graduate student at Guelph, Adam Harrington, is doing research on SGRP strain 85XC.

Collaborative work on disease, with M. Burt, W. Lynch and T.J. Benfey, of the University of New Brunswick, G.B. Bacon, of the Research and Productivity Council, and the N.B. Salmon Growers' Association, is being planned. This work has been extended to examine family variation in resistance to sea lice in cooperation with Dr. B. MacKinnon, of the University of New Brunswick.

Collaborative work with J.A. Ritter, DFO, and R.W. Doyle, Dalhousie University, is being planned in connection with cage escapees.

Preliminary development of a technical bulletin on Sea Ranching will be supplemented by input from G. Farmer, DFO.

Cooperative work with C. Exley, University of Stirling, Scotland, is being conducted on aluminum and silicon content of water from concrete and fibreglass tanks.

iii. Communications -

Meetings with growers and enhancement managers.

Involvement in trade shows.

Publications described below.

Presentations to visiting groups.

Popular press.

Participation in scientific meetings:

Bailey, J.K. and G.W. Friars. 1991. Are feral Atlantic salmon likely to have a quantitative

genetic impact on wild populations? DFO Conference in Nanaimo, B.C., June 3-8 (poster).

Bailey, J.K., F.M. O'Flynn and G.W. Friars. 1991. Genetic and phenotypic correlations among freshwater growth traits in Atlantic salmon. *Aquacult.* '91, St. Andrews, N.B.

Benfey, T.J. and G.W. Friars. 1991. The production of all-female triploid Atlantic salmon. Abstracts from a presentation to the Atlantic Universities Aquaculture Conference, March 8-9, 1991. St. Mary's University, Halifax, N.S., M.J. Dadswell, Chairman.

Friars, G.W. 1991. Breeding Atlantic salmon for performance in sea cages. 47th Ann. N.E. Fish and Wildlife Conf.

Friars, G.W. 1991. Selection for resistance to disease in a breeding program for Atlantic salmon. DFO Fundy Region 14th Fish Health Workshop, p. 7.

Friars, G.W. and J.K. Bailey. 1991. Time trends in returns from sea coupled with genetic equilibrium in Atlantic salmon (*Salmo salar*). DFO Conference in Nanaimo, B.C., June 3-8 (poster).

Friars, G.W., J.K. Bailey and F.M. O'Flynn. 1991. Application of selection indexes in Atlantic salmon (*Salmo salar*). 4th Int. Sym. on Gen. in Aquacult., Wuhan, China, April 28-May 3.

Hanke, A.R., G.W. Friars, J.M. Terhune. 1991. The effect of competition of the ranks of Atlantic salmon families with different hatching times in a grilse and a two-sea-winter stock. *Aquacult.* '91, St. Andrews, N.B.

O'Flynn, F.M., G.W. Friars, J.K. Bailey and J.M. Terhune. 1991. The development of a linear selection index in Atlantic salmon. *Aquacult.* '91, St. Andrews, N.B.

iv. Contracts Administered -

v. Other -

Primary breeder for the N.B. Salmon Growers' Association.

## 7. Publications:

i. Primary -

Friars, G.W. 1991. Some tests and applications of quantitative genetics theory in trifolium poultry and fish. *Informacion Technica Economica Agraria*, Vol. 87A. Nos. 2-3, p. 103-107.

Hanke, A.R., S. Backman, D.J. Speare and G.W. Friars. 1991. An uncommon presentation of fungal infection in Atlantic salmon fry. *J. Aquat. Anim. Health* 3: 192-197.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Anonymous. 1991. SGRP Annual Report 1990/91.

Anonymous. 1991. Atlantic Salmon Workshop. Proceedings from a workshop held on October 17, 1989, St. Andrews, N.B., SGRP Report Series 131.

Friars, G.W. and T.J. Benfey. 1991. Triploidy and sex reversal in relation to selection in the Salmon Genetics Research Program. *Can. Tech. Rep. Fish. Aquat. Sci.* No. 1789, p. 81-83.

Friars, G.W., J.K. Bailey and K.A. Coombs. 1991. Some aspects of selection in aquaculture, p. 85-92. In R.H. Cook and W. Pennell (eds.) Proceedings of the special session on salmonid aquaculture, World Aquaculture Society, February 16, 1989, Los Angeles, USA. *Can. Tech. Rep. Fish. Aquat. Sci.* 1831.

Soto, C.G., 1991. Fertilization and mortality rate of Atlantic salmon (*Salmo salar*) eggs during incubation. *SGRP Rep. Ser.* No. 134.

iv. Popular and Miscellaneous -

Anonymous. 1991. Newsletter on Salmon Genetics Research Program, April 1991.

Scott, S.A. 1991. Genetics plays key role in 1990 returns to the SGRP. *Atlantic Salmon Journal*, 40 (1), p. 14.

Scott, S.A. 1991. Workshop on broodstock development. *Salar*, May, 1991.

## 8. Review and Evaluation:

The SGRP has been undergoing significant change in the last few years with the increasing focus on the development and selection of strains for salmon aquaculture. The direct participation of the NBSGA and the New Brunswick Department of Fisheries and Aquaculture, have strengthened the program. The re-orientation of strain improvement to meet aquaculture production objectives has received

strong industry support. The program is well managed by the Atlantic Salmon Federation and collaborative research with DFO scientists and the universities is very productive. The involvement of the SGRP in research to assess the problem of aquaculture salmon escapees on wildstock is relevant and timely. This program is continuing to develop and is a long-standing example of DFO private sector science collaboration.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 402

Section: Aquaculture

Project Title: Salmonid Growth, Smolting and Reproduction

Project Leader: Saunders, R.

Other Researchers: Harmon, P.; Knox, J.D.; Duston, J. and Hovey, A. (IRAP-R project with Connors Bros.)

Work Activity: W.A.1.1.2.2

Key Words: salmon; aquaculture; salmonid culture; physiology

1. Project Description:

Conduct physiological research on salmonid growth and smolting to elucidate effects of environmental manipulation on metabolism, growth and behaviour; evaluate smolting on the basis of endocrinological, metabolic and osmoregulatory activity; investigate environmental and genetic bases for age-at-maturity of Atlantic salmon; conduct field tests on sea farms to scale-up promising lab results; transfer salmonid culture technology to private sector through contact with commercial marine and freshwater salmon producers.

2. Long-Term Objectives:

Provide solutions to biological problems encountered or anticipated in salmonid aquaculture; improve the quality and cost-effectiveness of producing salmon smolts for aquaculture and enhancement of wild populations; improve the productivity and cost-effectiveness of salmonid aquaculture through a better understanding of the environmental and genetic control of age-at-maturity; develop and perfect methods of controlling maturity; participate in an effective extension service for the salmonid aquaculture industry by cooperative research and technology transfer with salmonid aquaculture companies and by receiving feedback from new R&D initiatives.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue study of underyearling smolt production in Atlantic salmon with emphasis on early production. (Saunders, Duston)

Success appears to depend on fish reaching smolt size before experiencing winter photoperiod. A high percentage of the population is showing smolt-like salinity tolerance in October-November.

2. Investigate natural occurrence, genetic basis and possible use as a genetic marker of spotted fins in Atlantic salmon. (Saunders)

We did not undertake this work because of inadequate lab space and funds.

3. Report findings of attempts to acclimate parr to seawater in autumn. (Duston)

Paper in press in Aquaculture.

4. Report findings from experiment on effects of different levels of dietary omega-3 fatty acids in salmon. (Ackman, Saunders)

Paper on levels of omega-3 fatty acids and their stability published in J. Food Process. Preserv.

5. Investigate alternate tissues for enzyme for bioassay of fish growth. (Benfey, Saunders)

Muscle, but not liver, appears to be a good tissue for assay of enzyme closely associated with growth.

6. Initiate cooperative experiment with Connors Bros. on reduction of maturation as grilse in Atlantic salmon deprived of food during various periods in winter-spring if AFAP funding approved. (Saunders, Frantsi)

The sea cage component of the study is underway. AFAP funding has been provided in December 1991 for the remainder of the fiscal year. A lab component is being done using my operating budget.

4. Additional Accomplishments:

1. Participating in study of transgenic salmon with added growth hormone as part of an NSERC strategic grant project with scientists from University of Toronto, Queen's University and Memorial University of Newfoundland.
2. Conducted experiment in cooperation with SGRP to evaluate smolt status of salmon reared in

concrete vs fibreglass rearing tanks.

#### 5. Goals/Expected Outputs for 1992:

1. Hatch and rear transgenic (growth hormone) salmon and evaluate effects of extra copies of GH on growth and smolting. (Saunders, Fletcher)
2. Continue study of underyearling smolt production with follow-up evaluation of long-term survival and growth in seawater. (Saunders, Duston)
3. Evaluate smolt production from previously mature male parr. (Saunders)
4. Conduct study in cooperation with Connors Bros., re effectiveness of food deprivation in winter-spring on grilse maturation. (Saunders, Frantsi)
5. Report findings of cooperative study with SGRP, re smolt production in concrete vs fibreglass rearing tanks. (Saunders, Friars)
6. Evaluate influence of photoperiod and temperature on development of bimodality in length frequency as an indication of incipient smolt status. (Saunders, Duston)

#### 6. Background:

##### Highlights:

Participated in Helsinki meetings of ICES Genetics and Introduction and Transfers Committees.

##### Selected Involvements:

##### i. Collaborative Research -

With James Duston, of Connors Bros., on autumn transfer to seawater and smolt development of juvenile salmon under terms of IRAP-R contract; with personnel of SGRP, re evaluation of smolt status of salmon grown in concrete and fibreglass rearing tanks.

##### ii. University Liaison -

Completed studies of omega-3 fatty acids in salmon with Dr. R. Ackman, of Technical University of N.S.; with Dr. Tillmann Benfey, of University of New Brunswick, re enzyme bioassay of salmon growth; completed study of coronary arteriosclerosis in salmon with Dr. A.P. Farrell, Simon Fraser University; served as opponent for Ph.D. thesis examination at University of Umeå, Sweden; began NSERC-sponsored study of growth hormone transgenic salmon with staff from University of Toronto, Queen's and Memorial Universities.

##### iii. Communications -

Presented lecture to students in Aquaculture Technician Training Program, N.B. Community College; DFO press release, re environmental manipulation of juvenile salmon growth.

##### iv. Contracts Administered -

##### v. Other -

Serving as Scientific Advisor, re IRAP-R contract with Connors Bros., Aquaculture Division.

Liaison Officer for two DFO Science Subvention projects.

#### 7. Publications:

##### i. Primary -

Duston, J., R.L. Saunders and D.E. Knox. 1991. Effects of increases in freshwater temperature on loss of smolt characteristics in Atlantic salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 48: 164-169.

Rourke, A.W., R.L. Saunders and P.R. Harmon. 1991. Changes in plasma protein patterns in smolting Atlantic salmon, Salmo salar L., are not dependent on changed growth rates. J. Fish. Biol. 39: 35-43.

Lubin, R.T., A.W. Rourke and R.L. Saunders. 1991. Influence of photoperiod on the number and ultrastructure of gill chloride cells of the Atlantic salmon (Salmo salar) before and during smoltification. Can. J. Fish. Aquat. Sci. 48: 1302-1307.

Polvi, S.M., R.G. Ackman, S.P. Lall and R.L. Saunders. 1991. Stability of lipids and omega-3 fatty acids during frozen storage of Atlantic salmon. J. Food Process. Preserv. 15: 167-181.

McCormick, S.D., W.W. Dickhoff, J. Duston, R.S. Nishioka and H.A. Bern. 1991. Developmental differences in the responsiveness of gill Na<sup>+</sup>, K<sup>+</sup> - ATPase to cortisol in salmonids. Gen. Comp. Endocrinol. 84: 308-317.

Stefansson, S.O., B. Th. Björnsson, T. Hansen, C. Haux, G.L. Taranger and R. L. Saunders. 1991. Growth, parr-smolt transformation, and changes in growth hormone of Atlantic salmon (Salmo salar) reared under different photoperiods. Can. J. Fish. Aquat. Sci. 48: 2100-2108.

## ii. Interpretive Scientific -

Saunders, R.L. 1991. Potential interaction between cultured and wild Atlantic salmon. *Aquaculture* 98: 51-60.

## iii. Scientific and Technical -

Duston, J., D.E. Knox and T., Maynard. 1991. On producing 1.5' year-old Atlantic salmon smolts by photoperiod manipulation. *Bull. Aquacult. Assoc. Can.* 91-3: 41-43.

Saunders, R.L. 1991. Le concept de souche dans la gestion et la restauration des populations de saumon Atlantique. In Nicole Samson et Jean-Pierre le Bel (Eds.) *Compte Rendu de L'atelier sur le nombre de reproducteurs requis dan les rivières à saumon. Ile aux Coudres. Février 1988. Minist. du Loisir, de la Chasse et de la Pêche*, 65-80.

Saunders, R.L. 1991. Salmonid mariculture in Atlantic Canada and Maine, U.S.A., P. 21-36. In R.H. Cook and W. Pennell (Eds.) *Proc. Special Session on Salmonid Aquaculture, World Aquac. Assoc. February 16, 1989. Can. Tech. Rept. Fish. Aquat. Sci.* 1831.

Saunders, R.L. 1991. Canadian studies on gene technology, biochemical markers and means of reducing genetic interaction between cultured and wild salmon. 9 p. In Anon. 1991. *Report of the Working Group on Genetics. ICES C.M.1991/F:45. Mariculture Committee.*

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Data from the studies of environmental manipulation of juvenile salmon in relation to growth, smolting and sexual maturation have been reported in the scientific and technical literature. These reports are increasingly quoted and the data are being used as guides by fish farmers to increase numbers and effectiveness in smolt production. The effectiveness of the project owes much to successful collaboration with other scientists nationally and internationally and through contact with salmon growers.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 404

Section: Applied Ecology

Project Title: Phytotoxin Research

Project Leader: Wildish, D.

Other Researchers: Martin, J.L.; Wilson, A.

Work Activity: W.A.1.1.3.3

Key Words: aquaculture; phytotoxins; domoic acid; PSP

1. Project Description:

The aim of the research undertaken is to document phytoplankton autecology of species of microalgae which are harmful to finfish or bivalve molluscs, particularly those of commercial value. Individual projects are selected based on their practical relevance in resolving problems primarily in mariculture in the Bay of Fundy, but also in more traditional fisheries.

2. Long-Term Objectives:

To understand phytoplankton autecology of species harmful (or potentially harmful) to commercially valuable bivalve molluscs or finfish. This will allow remedial or inspection measures to be considered in the mariculture or traditional fisheries industries.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Undertake a temporal cluster analysis to determine annual, recurrent patterns in phytoplankton species and their density.

Considerable effort was expended in changing the data base (species, density and environmental parameters X time) from a form suitable for technical report publishing to one suitable for temporal statistical analysis. This work is still not completed. Preliminary attempts were made to choose a computer compatible temporal analysis for use with this large data base, inclusive of environmental variables, but there is now no expert advice regarding statistics in St. Andrews. One possibility to maximize the scientific value of this large, five-year data base is to allow Ms. Martin to explore different temporal analytical techniques following further training in these methods (half credit course at U.N.B.).

2. Continue a phytoplankton bloom dynamics monitoring project at 4 stations sampled regularly as part of the Scotia-Fundy program.

Sampling was completed satisfactorily to date, although some sample analyses are back-logged due to lack of contracted help in the identification laboratory. A technical report is in preparation detailing the 1990-1991 results.

3. Initiate a new project to determine the factors controlling the production of domoic acid in Nitzschia pseudodelicatissima.

A new incubator was commissioned during the year which enabled more culture experiments to be run. Various nutrient levels (N, PO<sub>4</sub>, Si) were tested. Microscopic observations showed that bacteria were present in the cultures. Tests are underway to obtain axenic cultures so that nutrient effects are free of microbial mediation.

4. To develop and test an automated flume in which seston and flow can be controlled. The laser diode system required for controlling seston levels in the flume is expensive (\$30K). Any further work on determining bivalve feeding rates when fed toxic microalgae is only possible if it is purchased (submitted to Scotia-Fundy Phytotoxin Advisory Committee).

The laser diode system was not purchased and a cheaper alternative, a flow-through Turner fluorometer, was tested, although this system has obvious limitations, e.g. can only be used where pure cultures of one species of microalgae are fed, it does appear possible to use it in these limited conditions as a seston controller. A new flume lab and new flume (the mini flow tank designed by M. Chin Yee) were installed in July. Experiments are currently underway to confirm that bivalve feeding can be monitored in the flow-through fluorometer.

5. Continue to determine the effects of toxic microalgae on the behaviour and physiology of finfish by conducting further screening bioassays involving open heart ECG's with 40-50 microalgae from the Bay of Fundy; conduct fish bioassays with implanted acoustic heart tags when challenged with 1 or 2 toxic microalgae.

Difficulty was found in obtaining repeatable control ECG's between different fish preparations.

Because of this difficulty, this bioassay has been abandoned - an unpublished report is being prepared on our results and experience.

The flume lab is currently (November) being prepared for these experiments (purchase of behavioral observation tank, purchasing and acclimating salmon smolts).

#### 4. Additional Accomplishments:

1. Gave advice to the industry through personal contacts, DFA and DOE (N.B.), the N.B. Salmon Growers Association (Martin, Wildish), DFO Inspection, Halifax, DFO Communications Branch, Ottawa, and DFO, Moncton. (Martin)
2. Reviewed manuscripts and research proposals inclusive of DFO Science Subvention proposals. (Wildish, Martin)
3. Presented "Distribution and domoic acid content of *Nitzschia pseudodelicatissima* in the Bay of Fundy" at the 5th International Conference on Toxic Marine Phytoplankton, Newport, Rhode Island, 28 October - 1 November, 1991. (Martin)

#### 5. Goals/Expected Outputs for 1992:

1. Determine the factors controlling the production of domoic acid in *N. pseudodelicatissima*.
2. Collaborate with K. Haya in a PSP study involving saxitoxin uptake and elimination in American lobsters.
3. Provide a reduced phytoplankton monitoring service to the salmonid aquaculture industry (four stations, surface water only, weekly from May - October), whilst at the same time maintaining a long time series analysis of phytoplankton of the SW mouth Bay of Fundy.
4. Complete development and testing of an automated flume, based on the Turner fluorometer as the seston controller. Undertake collaborative work with Dr. P. Lassus, IFREMER, Nantes, France, to determine the effect of locally important toxic microalgae on bivalve feeding rates.
5. Conduct fish bioassays with implanted heart tags to determine the effect of toxic microalgae on physiology and behaviour.

#### 6. Background:

##### Highlights:

Building and equipping a custom-designed flow simulation lab, including successful calibration of a new flume capable of velocities up to 100 cm.s<sup>-1</sup>.

##### Selected Involvements:

##### i. Collaborative Research -

Collaborative work with PCS group at St. Andrews continued to be mutually beneficial.

##### ii. University Liaison -

Significant liaison was maintained with the universities of Rhode Island, U.S.A., and Lund, Sweden.

##### iii. Communications -

Invited presentations were prepared for the Workshop on the Environmental Impacts of Mariculture organized by Canada/Norway: "Methods for determining benthic flora and fauna near mariculture sites" (D. Wildish) and "Determining the potential harm of phytoplankton blooms to cultured salmonids in seawater" (D. Wildish and J. Martin). The workshop to be held in Bergen, Norway was cancelled due to lack of travel funds by Canada.

##### iv. Contracts Administered -

One contract for phytoplankton identification. (J. Martin)

##### v. Other -

#### 7. Publications:

##### i. Primary -

Haya, K., J.L. Martin, L.E. Burrige, B.A. Waiwood and D.J. Wildish. 1991. Domoic acid in shellfish and plankton from the Bay of Fundy, New Brunswick, Canada. *J. Shell. Res.* 10: 113-118.

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Wildish, D.J. 1991. The flow simulation laboratory at St. Andrews Biological Station. *Can. M.S. Rep. Fish. Aquat. Sci.*

## iv. Popular and Miscellaneous -

Martin, J.L., K. Haya, L.E. Burrige and D.J. Wildish. 1991. Nitzschia pseudodelicatissima - a source of domoic acid in the Bay of Fundy, eastern Canada. In: D.C. Gordon (ed.) Proc. Second Canadian Workshop on Harmful Marine Algae. Can. Tech. Rep. Fish. Aquat. Sci. 1799: 14. (abstract)

Martin, J.L., D.J. Wildish and M.M. LeGresley. 1991. Phytoplankton monitoring in the Fundy Isles Region. In: D.C. Gordon (ed.) Proc. Second Canadian Workshop on Harmful Marine Algae. Can. Tech. Rep. Fish. Aquat. Sci. 1799: 14. (abstract)

Wildish, D.J., F. Bouvet, R.H. Peterson and J.L. Martin. 1991. The effect of marine, microalgal extracts on the salmon smolt electrocardiogram. In: D.C. Gordon (ed.) Proc. Second Canadian Workshop on Harmful Marine Algae. Can. Tech. Rep. Fish. Aquat. Sci. 1799: 28-29. (abstract)

8. Review and Evaluation:

This project continues to meet its long term objectives by being proactive in choosing individual research topics. In addition, solid progress has been made in:

- determining the source of production of domoic acid in the Bay of Fundy
- planning a temporal analysis of the Bay of Fundy phytoplankton data
- determining which phytoplankton species might be of potential harm to the salmonid mariculture and the commercial bivalve fishing industries.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 405

Section: Aquaculture

Project Title: Marine Finfish Aquaculture

Project Leader: Waiwood, K.

Other Researchers: Howes, K.; Reid, J.

Work Activity: W.A.1.1.2.2

Key Words: halibut; cod; haddock; marine fish culture

1. Project Description:

This project has focused on halibut (Hippoglossus hippoglossus) and consists of three research thrusts: broodstock development; juvenile production; and on-growing. Currently about 45 broodstock are held in a special facility and are producing over 20 liters of eggs per spawning season. On-growing studies have included the evaluation of modified herring weirs, salmon cages and specially-designed bottom cages. Egg and larval studies began in 1991.

2. Long-Term Objectives:

To develop technologies for the culture of marine finfish in support of the aquaculture industry in the Scotia-Fundy Region; to determine the feasibility of introducing new marine fish species and culture techniques for aquaculture purposes; to transfer technologies related to marine fish culture to industry, and to provide advice on physiological and behavioural problems related to the aquaculture of marine finfish in the Scotia-Fundy Region.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Submit for publication technical paper on Weir study.

The first draft of this paper has been prepared for submission as a technical report.

2. Continue research on collection of zooplankton (M.Sc. student project).

The first season of data collection was successfully completed. A time series of zooplankton collections was made. A poster paper entitled 'A simple method for the mass collection of zooplankton for early feeding marine fish' was presented at the Larvi '91, Ghent, Belgium, August 27-30, 1991. An oral presentation was made at the Atlantic Aquaculture Fair (June).

3. Initiate study on haddock feeding (M.Sc. student project), if funded by NSERC.

This study was not funded by NSERC however, several collections were made in May/June, 1991 and over 80 haddock were eventually placed in tanks in St. Andrews. Subsequently, 20 haddock were transferred to a salmon cage on Campobello Island. After some initial mortality, survival and growth have been good. The remainder of the fish were kept in St. Andrews to be used for broodstock. This represents one of the few (if not the only) haddock broodstock in captivity.

4. Initiate study on combined effect of salinity and flow rate on egg mortality.

A study on the effect of low salinity on egg development was initiated. Data on fertilization and hatching success, mortality, and developmental abnormalities has been analyzed. Preliminary results indicate that halibut eggs can be incubated in low ambient salinities. However, the studies show some benefit in increasing salinity in order to reduce flow rates. This indicated that the method of controlling salinity had to be refined.

5. Fabricate and assemble yolk-sac larval rearing systems and, if possible, initiate survival studies.

Despite numerous delays, incubators were eventually delivered and set up for yolk-sac larvae. Unfortunately, after the initial attempt no more eggs were obtained from the broodstock. The limited operation did, however, indicate that the water supply system had to be modified for the next year. This has been done.

6. Complete annual broodstock report.

Delays in staffing a technician position and the resultant increase in work loads has delayed preparation of this report.

7. Continue study on halibut bottom cage in cooperation with Washington County Community College, Eastport, Maine.

This cage has been modified to incorporate safety features. Construction is now complete. Halibut will be placed in this cage in the spring of 1992.

8. Continue study on halibut on-growing in modified salmon cages in cooperation with Harbour DeLoutre Products Ltd.

This study was continued another year. The preliminary results are very encouraging with 100% survival and excellent growth rates. These results strongly suggest that halibut on-growing in the Bay of Fundy is economically feasible using modified salmon culture methods.

#### 4. Additional Accomplishments:

1. Paper entitled "halibut (*Hippoglossus hippoglossus*) a potential aquaculture species for the Maritimes" was published in *Aquanotes* 16: 32-36.
2. A paper entitled "Low temperature feeding in cod (*Gadus morhua*)" by Waiwood, K.G., S.J. Smith and R. Peterson was published (*Can. J. Fish. Aquat. Sci.* 48(5): 824-831).

#### 5. Goals/Expected Outputs for 1992:

1. Continue on-growing studies on halibut and haddock with Harbour DeLoutre Products Ltd., Campobello.
2. Continue study on the on-growing of halibut in bottom cage with Maine Aquaculture Innovation Center (MAIC) and Marine Trade Center, Eastport.
3. Continue work on mass collection of zooplankton in conjunction with the MAIC and the University of Maine.
4. Complete experiments on effect of salinity on incubation of halibut eggs; analyze data.
5. Initiate studies on incubation methods for halibut yolk sac larvae including an evaluation of incubator type and effect of salinity on survival and development; analyze data.
6. Submit for publication Technical Report on halibut on-growing in weirs.
7. Present paper at 16th Annual Larval Fish Conference, Kingston, RI, June 17-19, 1991.
8. Present paper at conference on Broodstock Management and Egg and Larval, Quality, Stirling, Scotland June 23-27, 1991.
9. Conduct collaborative studies with Anders Mangor-Jensen (Austevoll, Norway) on water transport in fish eggs.

#### 6. Background:

##### Highlights:

We are pleased with the progress made with our on-growing studies. The results indicate a four-year production cycle for halibut is feasible with a three-year cycle as a long-term goal. So far, there is every indication that the on-growing aspect of halibut culture is economically feasible. Due to the current level of A-base support, egg and larval studies have progressed more slowly. It should be noted, also, that we did not receive the second year of funding from AFAP as applied for. On the other hand, we are very encouraged by successes in Norway this year which indicate that commercial quantities of halibut fry can be produced using current technology.

##### Selected Involvements:

##### i. Collaborative Research -

- with the Maine Aquaculture Innovation Center, University of Maine and North Atlantic Aquaculture Inc., on a growout study using bottom cages and a Masters student project on the collection of wild zooplankton for feeding larval fish.
- with Harbour DeLoutre Products Ltd. on a halibut grow-out study using modified salmon cages (funded by Canada - New Brunswick Cooperative Agreement on Fisheries and Aquaculture Development).
- with John Allen at the Huntsman Marine Science Centre, St. Andrews, on projects related to cage rearing of halibut.

##### ii. University Liaison -

- with the University of Maine, Orono, Maine, co-supervisor of a M.Sc. student
- with University of New Brunswick, Honorary Research Associate
- with the N.B. Community College, supervision of a summer student and presentation of several lectures

##### iii. Communications -

Bulletins/Newspapers: Atlantic Fish Farming, June 20, 1991, "Halibut eggs do well" by Laura Haley; Sou'wester, February 28, 1991, "Canada looks at halibut aquaculture" by Thea Smith; Northern Aquaculture, "Halibut culture prospects encouraging" by Suzanne Taylor; Fish Farming International, July, 1991, "Canada program assists three research projects"; The Quoddy Tides, September 2, 1991 "Halibut raising could be wave of future" by E. French; Telegraph Journal, November 30, 1991, "Halibut may change direction of aquaculture", by D. Gowan; St. Croix Courier,

November 26, 1991, "Grower tries raising haddock" by T. Lockhart;

TV: ASN Interview and news feature on Alive at Five by Lavern Stewart, October 24, 1991.

Other: DFO Backgrounder, June 3, 1991. "Aquaculture research programs receive AFAP funding". Weekly Scientific Briefing, "On-growing studies with halibut continuing", by K.G. Waiwood.

iv. Contracts Administered -

1. Canada - N.B. Cooperative Agreement on Fisheries and Aquaculture Development (\$38K) for halibut on-growing study in modified salmon cages.
2. Scientific authority on MAIC grant for the development of methods for the mass collection of zooplankton (\$20K US).

v. Other -

7. Publications:

i. Primary -

Waiwood, K.G., S.J. Smith and M.R. Peterson. 1991. Feeding of Atlantic cod (Gadus morhua) at low temperature. Can. J. Fish. Aquat. Sci. 48(5): 824-831.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Waiwood, K.G. 1991. Halibut (Hippoglossus hippoglossus) a potential aquaculture species for the Maritimes. Aquanotes 16: 32-36.

8. Review and Evaluation:

Considerable progress has been made in this major study in spite of a serious shortage of technical assistance during critical seasons for spawning and hatching. The cooperation projects with a weir operator and a salmon sea-cage operator have provided useful information which should help to answer important questions about grow-out feasibility and biological aspects of growth and suitability of cage-enclosures. Meaningful progress with spawning, incubation and rearing to the grow-out stage will depend heavily on having adequate help. The broodstock development component of the project is making good progress. Much useful information should come from the DFO workshop being organized by Dr. Waiwood to consider marine fish culture from a national perspective.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 406

Section: Applied Ecology

Project Title: Aquaculture Ecology Research

Project Leader: Wildish, D.

Other Researchers: Martin, J.L.; Wilson, A.

Work Activity: W.A.1.1.3.5

Key Words: aquaculture; habitat research; benthos

1. Project Description:

The aim of this work is to determine the extent and biological implications of habitat changes caused by the intensive culture of finfish or bivalve molluscs, so that remedial measures to minimize self pollution can be taken. The research involves collaboration with chemical and physical oceanographers in PCSB. Another aim is to research environmental factors influencing bivalve mollusc carrying capacity, so that cultured bivalve production can be predicted and therefore optimally managed.

2. Long-Term Objectives:

Fully understand all of the environmental factors influencing the holding capacity of cultured marine fish and the production of cultured suspension-feeding marine bivalve molluscs.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue a study of environmental factors influencing bivalve feeding rates. Will conduct experiments with bivalve molluscs to test the importance of gill bypass shunting as a mechanism for the observed decrease of filtration rate with increasing ambient flow. This work will be done in collaboration with Prof. D.D. Kristmanson, University of New Brunswick.

Two manuscripts have been accepted for publication in J. Exp. Mar. Biol. Ecol. on the interactive effect of velocity and seston concentration on bivalve feeding and the effect of flow on the growth of juvenile and adult giant scallops. A number of different techniques have been tried to assess the importance of gill bypass shunting during partial valve closures. These include pressure measurements at the exhalant and isokenetic sampling of exhalant flows. The former method has been discarded as impractical with the scallop exhalant and work with the latter continues but has yet to produce conclusive results.

2. The following benthic studies in relation to environmental effects of salmonid mariculture will be undertaken: completion of a seasonal study of sedimentary conditions near salmonid net pens, inclusive of data analysis and preparation of an MS; continue collaboration with PCS and HED in developing a holding capacity model for the L'Etang salmonid culture industry; continue collaboration with Dr. B.T. Hargrave, HED to determine realistic input parameters suitable for use in the holding capacity model. The focus of this work will be on microbial ecology and it will involve a PDF. The costs will be shared between AIFD and HED.

Seasonal benthic studies were completed as planned and two manuscripts are nearing completion on seasonal changes in benthic oxygen demand under a salmonid mariculture site (in collaboration with B. T. Hargrave) and on dissolved oxygen/nutrient conditions in the seawater above this site (in collaboration with P. Keizer). Collaboration with PCS and HED continued with a number of modelling workshops held during the year. A show and tell session with the salmon mariculture industry and its managers is planned for January, 1992, at which time progress to date on ecological modelling in the L'Etang to determine the holding capacity for salmonids will be presented. A collaborative project with B.T. Hargrave on the microbial ecology of salmonid net pen sites was cancelled because the PDF candidate selected, Dr. Karen Wiltshire, obtained a job elsewhere, and the funds to support it (from AFAP) did not materialize.

3. Develop a research proposal (and obtain funding for it) to determine "The effects of dissolved oxygen and temperature on salmon smolt growth." This information is needed by the aquaculture industry to show how environmental conditions can affect growth rates.

The project "The effects of dissolved oxygen and temperature on salmon smolt growth" was initiated in a small way with student help at the Huntsman Marine Science Centre. Funds are still being sought from NRC for this project through Dr. Brian Glebe, of HMSC. It is hoped to have the project underway by spring, 1992.

#### 4. Additional Accomplishments:

1. Acted as co-chairman with Dr. Barry Jones (N.B. Department of Fisheries and Aquaculture) of the N.B. Aquaculture Environmental Coordinating Committee. Gave advice to the industry via the N.B. Salmon Growers Association. During the year, an environmental monitoring project designed by DJW became operational (Wildish and N.B. Department of Environment)
2. At the request of Habitat Management (A. Ducharme), undertook studies in Blacks Harbour to delimit the extent of pollution caused by a large fish processing facility. The work was done in collaboration with Dr. V. Zitko, PCS, and a report was prepared (see section 7 (iii)). (Wildish, Wilson)
3. Gave advice to environmental consultants regarding pulp mill pollution in L'Etang and acted as expert witness for the Crown in a court action in which the pulp mill was charged with exceeding the PME regulated levels of BOD and suspended solids. (Wildish).
4. Undertook training of Mr. Peter Fenety in environmental matters related to aquaculture. Mr. Fenety was on lateral transfer from DOT (Air Traffic Controller) and hoping to redeploy in the aquaculture industry. (Wildish, Wilson)
5. Reviewed manuscripts received from primary journals or from colleagues for pre-review. Also reviewed a few research proposals from the Natural Sciences and Engineering Research Council - two individual applications and one infrastructure grant. (Wildish)

#### 5. Goals/Expected Outputs for 1992:

1. Continue a study of environmental factors influencing bivalve feeding rates. Emphasis will be on behavioural responses to velocity. Part of the work will involve a collaborative project on bivalve molluscs feeding on toxic microalgae with Dr. P. Lassus, IFREMER, Nantes (see project 404). Will organize a fifth benthic workshop to be held in the fall of 1992 at St. Andrews. (Wildish, Wilson)
2. Undertake a review of the literature regarding flow as an environmental factor affecting suspension feeding benthic animals. (Wildish)
3. Continue the study "The effects of dissolved oxygen and temperature on salmon smolt growth" with Dr. Brian Glebe, of Huntsman Marine Science Centre. The project is focused on determining potential effects of low dissolved oxygen on feeding and growth by salmon. (Wildish)
4. Organize a fifth benthic workshop at St. Andrews in collaboration with J. Grant and B.T. Hargrave on "Marine Benthos and Flow". (Wildish)

#### 6. Background:

##### Highlights:

Use of a video camera to record changes in the scallop exhalant associated with velocity related changes suggests that valve closure is the mechanism of feeding inhibition. Also the commissioning of the new flow simulation lab occurred in July of 1991.

##### Selected Involvements:

##### i. Collaborative Research -

Continued collaboration with R. W. Trites (PCS) and B.T. Hargrave (HED) on developing input data for a salmonid holding capacity model. Initiated new collaborative projects with Dr. B. Glebe (HMSC) and Dr. P. Lassus (IFREMER, France).

##### ii. University Liaison -

Honorary Research Associate at UNB.

Co-supervision of Mr. Luc Roseberry at the Université du Québec à Rimouski.

##### iii. Communications -

Gave radio and TV interviews concerning the environmental effects of mariculture and L'Etang pulp mill pollution.

Wrote an article for Science Review 1990-91 on "Effect of flow on mollusc suspension feeding".

##### iv. Contracts Administered -

Two personal service contracts for laboratory assistants - \$50K.

##### v. Other -

#### 7. Publications:

##### i. Primary -

Wildish, D.J. and B. Frost. 1991. Volumetric growth in gammaridean Amphipoda. *Hydrobiologia*. 223: 171-176.

Wildish, D.J., A.J. Wilson and B. Frost. 1992. Benthic boundary layer macrofauna of Browns Bank, N.W. Atlantic as potential prey of juvenile benthic fish. *Can. J. Fish. Aquat. Sci.* 49: 153-160.

Chevrier, A., P. Brunnel and D.J. Wildish. 1991. Structure of a suprabenthic shelf sub-community of gammaridean amphipoda in the Bay of Fundy compared with similar sub-communities in the Gulf of St. Lawrence. *Hydrobiologia*. 223: 81-104.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Wildish, D.J. and V. Zitko. 1991. Chemical oceanographic conditions in Black's Harbour, N.B. in 1989-1991. *Can. MS. Rep. Fish. Aquat. Sci.* 2132: 11 p.

iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

With the cooperation of HED scientists from B.I.O., good progress has been achieved in producing a holding capacity model of the salmon mariculture industry at least within the L'Etang. A workshop designed to bring this knowledge to the industry and its managers is planned for early 1992. The building of the new flow simulation laboratory at St. Andrews should enable fundamental discoveries regarding bivalve mollusc feeding, growth and behavior to be made which will have practical importance in culture of these species. It is recommended that these opportunities are rigorously pursued over the next few years.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 407

Section: Aquaculture

Project Title: Effects of Low pH on Salmonid Development

Project Leader: Peterson, R.

Other Researchers: Martin-Robichaud, D.; Lacroix, G.

Work Activity: W.A.1.1.3.2

Key Words: acid rain; salmon

1. Project Description:

Investigate the influence of low pH on physiological processes, such as ion transport and behaviour of developing salmonid eggs and alevins. Carry out lake and stream surveys to determine the limits imposed by lake and stream pH distribution of fish and fish food organisms.

2. Long-Term Objectives:

Prediction of how low pH and other ionic concentrations interact to affect early fish development, and establishment of acceptable pH limits. Ability to predict how increased acidification will limit fish and fish food resources. Note that goals for 1988 in the 1988/89 PREP have changed.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Complete publication of experimental results.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. I anticipate that sufficient material for one more publication, on adsorption of Al to the salmon chorion, is on file. This data will be written into a manuscript in 1992/93. I suggest this project be cancelled after 1992/93.

6. Background:

## Highlights:

Factors related to stream size and alkalinity were most influential in determining fish and stream insect species associations in three catchments of N.B. and N.S. The lower limiting mid-summer pH levels for creek chub, salmon, brook trout and eel are 5.2, 5.0, 4.7 and < 4.5, respectively.

## Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
  1. Peterson, R.H. and P. McCurdy. 1991. Fish distribution in three watersheds of N.B. and N.S., a poster presentation at the 'International Symposium on the production of juvenile Atlantic salmon in natural waters'; St. John's, Nfld., January 25-27.
  2. Peterson, R.H., L. Van Eeckhaute and D. Gale. 1991. Distribution of fish, mayflies, caddisflies and stoneflies in three coastal watersheds of N.B. and N.S., Canada, an oral presentation at the American Fisheries Society annual meeting, San Antonio, Texas, September 8-12.
- iv. Contracts Administered -
- v. Other -

Donated voucher specimens from the insect surveys to the N.B. Museum, Atlantic Reference Centre, and Royal Ontario Museum; provided research specimens to S.K. Burian (South Connecticut State

University) and K.L. Schmude (University of Wisconsin).

7. Publications:

i. Primary -

Peterson, R.H. and D. Gale. 1991. Fish species associations in riffle habitat of streams of varying size and acidity in New Brunswick and Nova Scotia. *J. Fish. Biol.* 38: 859-871.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to make major contributions to understanding of the influence of low pH on ion transport, and other physiology and behavior of developing salmonid embryos and alevins.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 408

Section: Aquaculture

Project Title: Environmental Requirements for Early Fish Development

Project Leader: Peterson, R.

Other Researchers: Martin-Robichaud, D.

Work Activity: W.A.1.1.2.2

Key Words: salmon; striped bass culture; marine fish culture

1. Project Description:

Investigate the ways in which environmental perturbation and culture conditions can affect the physiology and early development of fish.

2. Long-Term Objectives:

Determination of optimal environments for culture of early stages of fish. Prediction of how environmental changes can affect fish populations through effects on early life stages.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Initiate experiments to examine the influence of various ambient salinity-temperature combinations on chloride cell and osmoregulatory responses of juvenile striped bass.

Two experiments were performed with juvenile bass. In the first, striped bass juveniles were adapted to 0, 15 and 30‰. The gills were then excised and fixed for light and electron microscopy. Histology and photomicrography are being performed by the U.N.B. microscopy unit. In the second experiment, freshwater-adapted striped bass were transferred directly to full seawater. Fish were sampled at various times after seawater exposure for changes in blood osmolality and gill ATPase, as compared to bass retained in freshwater. Analyses are continuing.

In a third experiment, newly-hatched striped bass larvae were reared through yolk resorption at all combinations of four temperatures (12, 15, 18, 21°C) and four salinities (0, 1, 5, 10 ‰). Embryo and yolk water contents, dry weights, and larval lengths were measured. Final larval length at first feeding is greater at 15°C, than at 18 and 21°C. There appears to be an interaction between salinity and temperature on growth. At 18°C and 21°C, larval water content was lower at 5 and 10‰ toward the end of yolk resorption - indicating water regulatory problems. This problem was not apparent at 15°C, and the experiment was not continued long enough at 12°C to reach the critical stage.

2. Complete the investigation of optimal temperature for growth of elvers.

Elver growth has been investigated at 2°C intervals, from 14 to 28°C. Optional growth occurred at 22.5°C. Results are currently being analyzed.

3. Continue sex reversal experiments with lumpfish eggs and juveniles by incorporating estrogen into the brine shrimp organisms.

Estrogen was successfully incorporated into live artemia, as determined by radio-immuno-assay. Artemia loaded with estrogen were fed to larval lumpfish at various stages of development, which were also exposed to dissolved estrogen. A histological time series of lumpfish development has been performed to determine when sex can be reliably assessed. The experimental fish will be reared to a size suitable for sex determination.

4. Investigate the influence of ambient calcium on yolk utilization by salmon alevins.

The results of the latest experiments were inconclusive. This project has been put on hold for the time being.

5. Construct a solar greenhouse over the experimental ponds to extend the season for plankton production.

Construction is contingent upon AFAP funding.

4. Additional Accomplishments:

1. Striped bass broodstock maintenance procedures resulted in spawning of viable eggs for the first time at St. Andrews in June, 1991. The progeny were used in experiments, as described in the previous section. Larvae and juveniles were also provided to HMSC, Dr. D. Conover (SUNY, Stony Brook), and Connors Bros. The broodstock are kept under controlled temperature-salinity-photoperiod regimes. Locomotor behavior is monitored to see how it changes in relation to

environmental change and sexual maturation.

#### 5. Goals/Expected Outputs for 1992:

1. Continue to study the influence of environmental variables on the dynamics of yolk utilization and water and ion movements in larval fish. Experiments in 1992 will focus on comparisons of an estuarine spawner (striped bass), and a marine spawner (cod and/or haddock); and on developing techniques for estimating yolk and embryo wet and dry weights for the small larvae. We also hope to develop a predictive model of water change in salmon alevins, as influenced by substrate and ambient temperature. The cod/haddock experiments are joint projects with Marine Fish Division (E. Trippel), and are contingent upon acquisition of a post-doctoral researcher, with 1992 a set-up year.
2. Investigate the influence of the physical characteristics of shelter on growth, feeding and stress in elvers. This project will probably involve a Ph.D. candidate (Collaboration with T. Benfey, UNB).
3. Complete the lumpfish sex reversal experiments.
4. Begin to examine the electrical properties of vitelline membranes in relation to water and ion permeability.
5. Continue exploratory experiments on the neurophysiology of triploid fish.

#### 6. Background:

##### Highlights:

Successful production of viable eggs from captive striped bass broodstock.  
Determination of temperature for optimal elver growth.  
Incorporation of estrogen into artemia.

##### Selected Involvements:

##### i. Collaborative Research -

Preliminary experiments with T. Benfey (U.N.B.) on differing neurophysiological properties of triploid and diploid fish.

##### ii. University Liaison -

U.N.B. - research on sex reversal of lumpfish is part of a M.Sc. program by D.J. Martin-Robichaud.

Ecole superieur D'Agriculture D'angers: supervised on-site practical training in aquaculture for two students from France.

##### iii. Communications -

Lectured New Brunswick Community College Aquaculture students on alternate fish species as aquaculture candidates.

Presented a paper on striped bass culture methods, at the Aquaculture Association of Canada annual meeting, St. Andrews, N.B., June, 1991.

D.J. Martin-Robichaud presented a paper on the lumpfish as an alternate aquaculture candidate, at the Aquaculture Association of Canada annual meeting, June, 1991.

##### iv. Contracts Administered -

Gill histology of striped bass adapted to various salinities, U.N.B., \$4.0K.

##### v. Other -

#### 7. Publications:

##### i. Primary -

Peterson, R.H., J. Power and D.J. Martin-Robichaud. 1991. Morphological basis of the pectoral fin flutter of embryonic Atlantic salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 48: 2223-2227.

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Peterson, R.H. (ed.). 1991. Proceedings of a workshop on biology and culture of striped bass (Morone saxatilis). Can. Tech. Rep. Fish. Aquat. Sci. 1832: v. + 66 p.

Martin-Robichaud, D.J., R.H. Peterson and L. Crim. 1991. Striped bass (Morone saxatilis) research at the Biological Station, Department of Fisheries and Oceans, St. Andrews, N.B. Can. Tech. Rep. Fish. Aquat. Sci. 1832: 39-45.

##### iv. Popular and Miscellaneous -

Peterson, R.H. 1991. Consideration for design of culture facilities for early stages of striped

bass (Morone saxatilis). Bull. Aquacult. Assoc. Canada 91 (3): 86-88.

Martin-Robichaud, D.J. 1991. Culture of lumpfish (Cyclopterus lumpus) for roe. Bull. Aquacult. Assoc. Canada 91 (3): 83-85.

8. Review and Evaluation:

The emphasis of this project is now on new fish candidates for aquaculture. The two researchers have made good progress in the study of early life history peculiarities and requirements of several species.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 409

Section: Applied Ecology

Project Title: Effects of Acid Rain Control Programs on Salmonid Recovery

Project Leader: Lacroix, G.

Other Researchers:

Work Activity: W.A.1.1.3.2

Key Words: acid rain; Atlantic salmon; recovery

1. Project Description:

Ecological and physiological responses of Atlantic salmon to temporal changes in chemistry in acidic rivers of Scotia-Fundy possibly linked to changes in sulphate deposition as a result of Canada-U.S. sulphur dioxide control programs.

2. Long-Term Objectives:

Determine the effects of the sulphur dioxide control programs and the resultant increase or decrease in environmental acidification on Atlantic salmon and its habitat, the rate and extent of aquatic recovery, and the need for further emissions reductions to protect fish habitat in rivers of Scotia-Fundy.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue to assume duties as coordinator of the Scotia-Fundy LRTAP Program and on the DFO LRTAP Subcommittee. (Lacroix)

Successfully coordinated an integrated regional research and monitoring program and maintained regional funding at a time of National Program change and reorientation.

2. Submit a manuscript evaluating the effects of applying limestone gravel in an acutely acidic stream on water chemistry and on fish populations for publication. Continue to assess the long-term effectiveness of the methodology and the recovery of fish populations. (Lacroix)

A paper was accepted for publication in Environmental Pollution; the proofs have been revised and the paper will be published shortly. The project has entered a second phase where the pH has been increased further by streambed liming, and the effects on chemistry and fish will be monitored.

3. Complete the determinations of aluminum in fish gills and the analysis of data from several experiments, and prepare a manuscript examining the seasonal differences in the responses of salmonids to low pH, and the mechanisms of effect during chronic and acute acid exposures in streams of Nova Scotia. (Lacroix)

Gill Al content has been determined, the data have been statistically analyzed, and a draft of a manuscript is under preparation for internal review.

4. Complete the analysis of histopathologic data, and collaborate in the preparation of a manuscript on the dynamics of aluminum in the gills of Atlantic salmon fry in relation to ambient concentrations of organic anions. (Lacroix, Peterson)

Scanning electron microscopy and histology of gill filaments has been completed. The histopathologic information has been quantified and a preliminary statistical analysis of the data has been completed.

5. Investigate the potential for silica to reduce or eliminate the toxicity of aluminum to fish in some acidified salmon rivers at times of low concentrations of organic anions. Conduct a laboratory study to evaluate the proposed silica-aluminum model of interacting in relation to toxicity in Atlantic salmon fry and to investigate the importance of competing organic anions. (Lacroix)

An experiment investigating the effects of complex solutions of aluminum, silica, and citrate under acidic conditions on Atlantic salmon fry survival and physiology was successfully completed. Water samples and some tissue samples have been analyzed.

6. Initiate a field study using sonic tracking to investigate the importance of passive and/or active movements and avoidance by juvenile salmonids, or lack thereof, in the responses of populations to acutely toxic acid episodes in chronically acidic streams of Nova Scotia. (Lacroix)

Laboratory tests were completed to evaluate the methodology and the effects of acoustic tag implantation in juvenile Atlantic salmon. Field trials to establish the tracking methodology were made. However, drought levels in the study rivers throughout the summer prevented more extensive tracking or progress.

7. Conduct preliminary analyses to examine the spatial and temporal trends in fish populations in acidic streams of Nova Scotia and use multivariate analyses to identify the important factor(s). Reevaluate and continue the sampling of fish populations as required to detect responses to changes in LRTAP. Conduct a background survey of fish species composition in some New Brunswick rivers with drainages in the Bay of Fundy, and continue the surveillance for acidification. (Lacroix)

Some statistical analyses to examine spatial and temporal trends have been completed but further tests will be conducted before a final decision is made concerning the fate of this juvenile salmon monitoring project. The survey of N.B. rivers for fish and chemistry was cancelled as a result of substantial reductions in funds.

8. Continue to assume a leading role and to collaborate in the development of models to assess the impacts of acid deposition on Atlantic salmon, and to analyze data and contribute information as required for the successful development of the various submodels. (Lacroix, DFO scientists from several Divisions)

Successful development and evaluation of the Atlantic Salmon Regional Acidification Model (ASRAM) prototype in collaboration with ESSA was completed. Phase II, hydrochemistry modelling and sensitivity analyses of the models, has begun and relies extensively on my long-term data sets from N.S. rivers.

#### 4. Additional Accomplishments:

1. Published article on "Impacts of acid rain on ~~habitat~~" for the 1988-89 Biennial Science Review. (Lacroix, Watt, Uthe)
2. Published a summary of DFO LRTAP research in the Report of The Atlantic Region LRTAP Monitoring and Effects Working Group. (Lacroix)
3. Published CAPSAC research document for ACFE Subcommittee for "Provision of scientific advice on the measurement of the productive capacity of fish habitats". (Lacroix, McCurdy)

#### 5. Goals/Expected Outputs for 1992:

1. Investigate the importance of movements (preference/avoidance) by juvenile salmonids in the responses of populations to acid episodes in chronically acidic streams of Nova Scotia using sonic tracking. (Lacroix)
2. Collaborate in a study of the sublethal effects of acidity on physiological debt and chemoreception in Atlantic salmon from a developmental perspective. (Lacroix, Morin, Hara, Eales)
3. Assume duties as coordinator of the Scotia-Fundy LRTAP Program and on the DFO LRTAP Subcommittee. (Lacroix)
4. Assume a leading role and collaborate in the continued development of the Atlantic Salmon Regional Acidification Model (ASRAM) and Hydrochemical Submodel. (Lacroix, DFO scientists from several Divisions, ESSA)
5. Prepare and submit a manuscript examining the seasonal responses of salmonids to low pH and the physiological effects of chronic versus acute acid exposures in streams of Nova Scotia. (Lacroix)
6. Analyze laboratory findings from the completed evaluation of the proposed silica-aluminum model of interaction in relation to toxicity in Atlantic salmon fry and of the importance of organic anions. (Lacroix)
7. Evaluate the analysis of spatial and temporal trends in fish populations in acidic streams of Nova Scotia, and continue the sampling of fish populations as required to detect responses to changes in LRTAP in the Medway River. (Lacroix)
8. Continue to assess the long-term effectiveness of applying limestone gravel in an acutely acidic stream on water chemistry and the recovery of fish populations. (Lacroix)
9. Collaborate in the preparation of a manuscript on the dynamics of aluminum in the gills of Atlantic salmon fry in relation to ambient concentrations of organic anions. (Peterson, Lacroix)

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

Sublethal effects of acidity on chemoreception in Atlantic salmon. (P.-P. Morin, St. Andrews, J.G. Eales, University of Manitoba, T.J. Hara, DFO Winnipeg)  
 Development of the Atlantic Salmon Regional Acidification Model. (ESSA, DFO, DOE)  
 Al-DOC-Si interactions at low pH. (K.T. Kan, University of New Brunswick)

Histopathology of fish gills and sites of Al accumulation. (C.S. Belfry, University of New Brunswick)

ii. University Liaison -

Dr. P.G.C. Campbell, Institut national de la recherche scientifique, Université du Québec.  
 Dr. T.A. Haines, Zoology Department, University of Maine.  
 Dr. K.T. Kan, Department of Engineering, University of New Brunswick.  
 G.N. Bance and C.S. Belfry, Electron Microscopy Unit, University of New Brunswick.

iii. Communications -

iv. Contracts Administered -

Fish population studies in acidic streams (\$35K), Washburn and Gillis Associates Ltd.  
 Chemical analysis of water and biological samples from acidic streams (\$32K), K-F Laboratories.  
 Field and laboratory experiments in relation to acid rain effects on fish (\$53K), Statcom Consultants.

v. Other -

Supervisor for Visiting Fellow in Canadian Government Laboratory (1991-92).  
 Member of Graduate Steering Committee for two Ph.D. students at the Institut national de la recherche scientifique, Université du Québec.  
 Associate Graduate Faculty member, Zoology Department, University of Maine.

7. Publications:

i. Primary -

Lacroix, G.L. 1991. Mitigation of low stream pH and its effects on salmonids. Environmental Pollution. (In press.)

ii. Interpretive Scientific -

iii. Scientific and Technical -

Lacroix, G.L., W.D. Watt, and J.F. Uthe. 1991. Impacts of acid rain on habitat. In: Science Review 1988 & '89: 52-55. Department of Fisheries and Oceans, Dartmouth, N.S.

Lacroix, G.L. 1991. Cause and effect studies: Report on ongoing research (1990). In: D.A. Scruton, U.P. Williams, L.L. Fancey, and M.M. Roberge (eds). Proceedings of the 5th Annual Department of Fisheries and Oceans LRTAP Workshop: 56-66. Department of Fisheries and Oceans, 9-11 October 1990, St. John's, Nfld.

Lacroix, G.L. 1991. Impacts of acid rain on salmonid ecology. In: B.L. Beattie (ed). 1990 Report of The Atlantic Region LRTAP Monitoring and Effects Working Group: 23-24. Environment Canada, Atmospheric Environment Service, Bedford, N.S.

McCurdy, E.P., and G.L. Lacroix. 1990. Methods to measure pH. In: Collected Papers on Fish Habitat with Emphasis on Salmonids: 309-314. CAFSAC Research Document 90/77, Dartmouth, N.S.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

In addition to implementing a comprehensive research project on the ecological responses to salmonids in acidic rivers, the project leader has also served an effective role in the coordination of the Scotia-Fundy LRTAP program. The scientific aspects of the research are soundly based and are increasingly being recognized internationally. This research is contributing substantially to our knowledge of the implications of air borne pollutants on fish habitat. The problem of providing Dr. Lacroix with full-time technical support staff member needs resolution.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 410

Section: Invertebrate Fisheries

Project Title: Invertebrate Fisheries and Aquaculture Research

Project Leader: Aiken, D.

Other Researchers: Waddy, S.

Work Activity: W.A.1.1.2.2

Key Words: aquaculture; invertebrates

1. Project Description:

Biological and engineering research on invertebrate species that have commercial aquaculture potential.

2. Long-Term Objectives:

Obtain biological information on invertebrate species with commercial aquaculture potential, develop rearing systems and strategies for the culture of invertebrate animals, and contribute to enhanced economic return from invertebrates through aquaculture; effect the transfer of aquaculture scientific and technical information to the private sector and general public.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare and submit for publication an invited interpretative review on crustacean growth for CRC Reviews in Aquatic Sciences. (Aiken)

Interpretive review written, submitted and accepted. Now in press with CRC. (Aiken)

2. Facilitate transfer of aquaculture scientific and technical information to the private sector and general public through the compilation, editing and publication of technical and general articles and periodicals in the field of aquaculture. (Aiken)
  - a) Served as Editor-in-Chief of World Aquaculture, editing and publishing 4 editions of the journal comprising 52 technical and general articles in the field of aquaculture. (Aiken)
  - b) Edited, coordinated and published the "Proceedings of the Seventh Annual Meeting of the Aquaculture Association of Canada," (Halifax, NS). Bull. Aquacul. Assoc. Canada 90-4, 100 p. (Waddy)
  - c) Edited, coordinated and published the "Proceedings of the Eighth Annual Meeting of the Aquaculture Association of Canada," (St. Andrews NB). Bull. Aquacul. Assoc. Canada 91-3, 124 p. (Waddy)
3. Prepare and submit for primary publication a manuscript on strategies for manipulating the spawning time in female American lobsters. (Aiken)

Manuscript written and submitted for primary publication in the Canadian Journal of Fisheries & Aquatic Sciences. (Aiken)

4. Conduct a series of experiments on the influence of scotophase length on the metamorphic molt of larval lobsters. (Aiken)

Studies conducted and analyzed. Results presented at AAC meeting in June (St. Andrews) and published in the Bulletin of the Aquacul. Assoc. Canada. (Aiken)

5. Conduct a study to further define how season can alter the spawning response of lobster to temperature and photoperiod. (Aiken)

Study completed; analysis and writeup proceeding. (Aiken)

6. Serve on the organizing committee of the First International Workshop on the Culture of Bivalve Molluscs. (Aiken)

Workshop to be held in Orlando Florida, May 1992, in conjunction with the National Shellfisheries Association. (Aiken)

7. Continue experiments to evaluate the effect of photoperiod and temperature on gametogenesis and maturation of scallops. (Couturier)

Research phase of graduate study program completed.

4. Additional Accomplishments:

1. Completed proposal for scallop culture development in the Bay of Fundy and submitted it to AFAP for consideration. (Aiken)
2. Revised and submitted chapter titled "Aquaculture in Canada" for publication in a book edited by L.A. Parsons. (Aiken)
3. Organized and chaired a panel discussion on the impact of aquaculture on coastal real estate values for presentation to national meeting of Real Estate Appraisers. (Aiken)
4. Administered the Invertebrate Fisheries Section, coordinated fisheries assessments and aquaculture research activities in the Bay of Fundy, and served as a member of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC).

5. Goals/Expected Outputs for 1992:

1. Conduct a study to evaluate the effect of body size and aggressive capability on survival and growth of small juvenile lobsters under communal conditions. (Aiken)
2. Conduct a study to evaluate the effect of stocking density on survival, growth and social interaction of small juvenile lobsters under communal conditions. (Aiken)
3. Edit, coordinate and publish "World Aquaculture," the aquaculture science and technology journal of the World Aquaculture Society. (Aiken)
4. Organize, coordinate and preside over "Aquaculture Canada 92," the ninth Annual Meeting of the Aquaculture Association of Canada, to be held at the University of British Columbia, Vancouver BC, June 1992. (Waddy)
5. Edit, coordinate and publish the "Proceedings of the Ninth Annual Meeting of the Aquaculture Association of Canada." (Waddy)

6. Background:

Highlights:

The editing and publication of World Aquaculture has brought international recognition regarding Canada's successful development of a viable commercial aquaculture industry. The editing and publication of the Proceedings of the AAC annual meeting has kept industry aware of the latest research in aquaculture. Both of these activities contributed to DFO's mandate to communicate with its clients and transfer science and technology to the private sector.

Selected Involvements:

i. Collaborative Research -

Collaborative research conducted with French scientists resulted in one primary publication during the review year.

ii. University Liaison -

Adjunct Professor, Dalhousie University, and supervisor of PhD thesis work.

iii. Communications -

Effectuated communication of scientific and technical information to researchers and interpretive information to entrepreneurs, growers and the general public through multilevel editorial involvements in World Aquaculture journal, the Bulletin of the Aquaculture Association of Canada, and the Proceedings of the Aquaculture Association of Canada.

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Charmantier, G., M. Charmantier-Daures, S.L. Waddy and D.E. Aiken. 1991. Salinity tolerance and osmoregulation in the nemertean Pseudocarcinonemertes homari. Can. J. Fish. Aquat. Sci. 48: 209-214.

Charmantier, G., M. Charmantier-Daures and D.E. Aiken. 1991. Metamorphosis in the lobster Homarus (Crustacea, Decapoda): a review. J. Crust. Biol. 11: 502-519.

ii. Interpretive Scientific -

Aiken, D.E. (Editor). 1990. World Aquaculture 21(4): 108 p.

Aiken, D.E. (Editor). 1991. World Aquaculture 22(1): 104 p.

Aiken, D.E. (Editor). 1991. World Aquaculture 22(2): 80 p.

Aiken, D.E. (Editor). 1991. World Aquaculture 22(3): 80 p.

iii. Scientific and Technical -

Aiken, D.E. and S.L. Waddy. 1991. Scotophase influences the metamorphic molt in lobsters. Bull. Aquacul. Assoc. Canada 91-3: 36-38.

Waddy, S.L. (Editor). 1990. Proceedings of the Annual Meeting of the Aquaculture Association of Canada. Bull. Aquacul. Assoc. Canada 90-4: 100p.

Waddy, S.L. (Editor). 1991. Bulletin, Aquaculture Association of Canada, 91-1, 92p.

Waddy, S.L. (Editor). 1991. Bulletin, Aquaculture Association of Canada, 91-2, 68p.

Waddy, S.L. (Editor). 1991. Bulletin, Aquaculture Association of Canada, 91-3, 128p.

Waddy, S.L. and D.E. Aiken. 1990. Introduction of spawning in preovigerous American lobsters. Bull. Aquacul. Assoc. Canada 90-4: 83-85.

iv. Popular and Miscellaneous -

Aiken, D.E. 1990. The otter's roar. World Aquaculture 21(4): 6-10 (Opening Shots).

Aiken, D.E. 1991. Aquaculture and the influenza virus. World Aquaculture 22(1): 2 (editorial).

Aiken, D.E. 1991. Focus on the Caribbean. World Aquaculture 22(1): 6-7 (Opening Shots).

Aiken, D.E. 1991. Will the problem go away if we ignore it? World Aquaculture 22(2): 2 (editorial).

Waddy, S.L. 1991. Seasonal variation in spawning response by lobsters (Homarus americanus) to temperature and photoperiod manipulation. Amer. Zool. 31: 138A (abstract).

8. Review and Evaluation:

The invertebrate fisheries and aquaculture program for the Bay of Fundy area has developed considerably during the review period as a result of the scientific leadership of this project. The contributions of the two doctoral students added considerably to the knowledge base being developed within the section.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 411

Section: Invertebrate Fisheries

Project Title: Soft-Shell Clam Fishery Research

Project Leader: Robinson, S.

Other Researchers: Chandler, R.; Martin, J.D.; Rowell, T.W.

Work Activity: W.A.1.1.1.3

Key Words: clams; assessments; ecology; assessment research

1. Project Description:

This is a long-term project designed to look at the basic population characteristics of the soft-shell clam, Mya arenaria, in the Scotia-Fundy Region. Abundance, population age structure, growth, mortality, condition, and reproductive aspects are being investigated, and how these attributes are affected by the fishery in different habitats.

2. Long-Term Objectives:

Provide a detailed and comprehensive data base on the basic ecology and population structure of the soft-shell clam, Mya arenaria, in the Bay of Fundy for support in future management decisions; assess the impact of various fishery practices on the soft-shell clam stocks.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue with the study of the Scotia-Fundy soft-shell clam fishery through the Clam Enhancement Program. Attempt to increase the presence of industry in the development of methods to increase the stocks, harvest, and/or production. (Robinson)

A fisherman-initiated project which examined the increase of natural spatfall was continued. Results indicated that the experimental treatments did result in significant increases in the natural spatfall. Other projects with fishermen examined the growth rate of clams in the Passamaquoddy Bay area. All of this work was done on a volunteer basis by fishermen as the funding for the Clam Enhancement Program did not materialize.

2. Continue the aerial surveys of clam digging effort in southwest New Brunswick. (Robinson)  
The decrease in O&M funding for this year resulted in the dropping of this project. A few flights are planned for the late fall and winter months.

3. Track the growth and natural mortality of a cohort of clams in Clam Cove on Deer Island and try to identify another cohort in one of our benchmark sites.

The growth and mortality of the cohort was successfully followed at the Clam Cove site and a new one was identified. Cohorts of newly settled clams were also found at Lepreau and the Block House (in St. Andrews).

4. Begin to survey the subtidal area of some local areas to determine the extent of the subtidal population.

A subtidal survey of the clam populations at the Block House (in St. Andrews) was initiated in the summer. Results indicated that population densities below the subtidal mark were very low.

5. Begin development of a sediment tray and methodology to determine recruitment of clams to an area.

A better technique to recover newly settled juveniles was developed which obviated the necessity to develop the tray methodology.

6. Continue research development on RNA/DNA ratios with respect to the sensitivity of the measurement at different feeding intensities.

A controlled experiment was conducted this summer which addressed the relationship of RNA/DNA ratios with respect to protein growth rates at different feeding levels. The samples are to be analyzed this winter.

7. Provide information to the industry and managers on the state of the clam stocks through industry meetings.

Clam meetings with industry were held in Digby and Black's Harbour. Results were presented on our work on settlement, growth etc.

4. Additional Accomplishments:

1. The project on historic sizes of clams through native indian shell middens was continued. Contact was made with the N.B. Provincial Museum and U.N.B. Fredericton to identify further sites for study. Through these contacts, a better protocol was developed for sampling the middens.
2. A new method for sampling newly settled clams was developed using a heavy liquid which was both safe and extremely effective. A manuscript was written and submitted to the primary journal *Limnology and Oceanography*.
3. The supervision of the construction of the invertebrate workboat at the local community college was undertaken.
4. The chairmanship of the St. Andrews Computer Advisory Committee was accepted for a one-year period.

5. Goals/Expected Outputs for 1992:

1. Continue with the study of the Scotia-Fundy soft-shell clam fishery through elements of the former Clam Enhancement Program. Attempt to increase the presence of industry in the development of methods to increase the stocks, harvest, and/or production. (Robinson)
2. Continue to survey the subtidal area of some local areas to determine the extent of the subtidal population. (Robinson)
3. Initiate a program to investigate the recruitment dynamics of the soft-shell clam in a few diverse local habitats to address the topics of growth, mortality, and habitat selection. (Robinson)
4. Provide information to the industry and managers on the state of the clam stocks through industry meetings. (Robinson)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

1. A study on the growth and mortality of juveniles was done in conjunction with Mr. Terry Rowell, from the Bedford Institute of Oceanography.
2. A study with Dr. Garth Fletcher, from Memorial University, is planned in order to look at the possible existence of antifreeze proteins in soft-shell clams.

ii. University Liaison -

1. The study was continued with Dr. Colin Bell, from Acadia University, to examine the ecological dynamics of bacterial populations in the marine environment with respect to soft-shell clams.
2. Dr. David Black was contacted, from the University of New Brunswick, regarding the pre-history of the soft-shell clam fishery. Future collaborations are planned.
3. Dr. Kyung Chung, from the Instituto Oceanográfico de Venezuela in Cumaná, Venezuela, visited our lab for three weeks to learn our RNA/DNA ratio approach to measuring growth and condition in animals.

iii. Communications -

1. Invited seminar at the Department of Fisheries and Oceans, Gulf Region, on the soft-shell clam fishery in the Scotia-Fundy Region, October 11, 1991.
2. Presentation of data at SWNS Clam Advisory meeting in Digby, Nova Scotia, October 9, 1991.
3. Weekly Scientific briefing on the Clam Enhancement Projects in Lepreau.
4. Presentation of data at SWNB Clam Advisory meeting in Black's Harbour, New Brunswick, October 21, 1991.
5. Co-editor of the Canadian Connection section in the newsletter of the National Shellfisheries Association.
6. Two interviews were given on CBC Radio on the soft-shell clam and its reproductive habits.

iv. Contracts Administered -

1. Soft-shell clam research support (\$6,900).
2. Clam Enhancement fishery survey (\$17,000).
3. Clam histology (\$300)

## v. Other -

1. Attended National Shellfisheries Conference in Portland, Maine.
2. Three manuscripts were reviewed for primary publication.

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

1. The Canadian Connection in the National Shellfisheries Association Newsletter (co-editor).
2. Bits and Bytes (Internal newsletter for computer events at St. Andrews Biological Station).

8. Review and Evaluation:

This project continues to develop nicely through a mix of collaborative and directed research, and is providing important information on the soft-shell clam resource.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 412

Section: Invertebrate Fisheries

Project Title: Scallop Population Dynamics and Assessment

Project Leader: Robinson, S.

Other Researchers: Chandler, R.; Martin, J.D.; Parsons, J.

Work Activity: W.A.1.1.1.3

Key Words: scallops; assessment research; ecology

1. Project Description:

Fishery related aspects of the population dynamics of the sea scallop, Placopecten magellanicus, are being studied in the New Brunswick area of the Scotia-Fundy Region.

2. Long-Term Objectives:

To understand and assess the stock structure and dynamics of the sea scallops in our mandated study area in order to provide advice for the efficient management of the fishery.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Conduct scallop assessment surveys on the New Brunswick side of the Bay of Fundy. Prepare CAFSAC summary sheet for 1990.

Scallop surveys were conducted in Passamaquoddy Bay, Fundy Isles, Grand Manan, and Cape Spencer. Results showed a similar pattern to last year, but there was some indication of an increased small recruitment pulse in some areas. Summary CAFSAC sheet prepared.

2. Continue with scallop spat project. Compare results from 1990 with 1989 and evaluate the success of settling on the bottom compared to the spat bags.

Spat distribution in 1990 compared very favourably with that observed in 1989 except that the settlement was approximately twice as high. Sampling using SCUBA at the collection stations suggests that settlement and/or survival is very habitat specific.

3. Redesign study to investigate selectivity of Digby scallop drags and assess immediate impacts on bottom.

Mechanical problems with the J.L. Hart resulted in the cancellation of our cruise at the end of October.

4. Examine the relationship between environmental parameters and the settlement time and success in scallop spat. (Parsons)

The field work has been finished and the sample analyses are nearing completion. The results are being incorporated into Parson's thesis.

5. Maintain effective communication linkages with scallop fishery representatives.

Attended ISAC meetings and presented material on meat counts and mortality events off Cape Spencer.

4. Additional Accomplishments:

1. The third annual report on meat counts was sent out to all the fishery offices in New Brunswick. This information will give the officers advance notice of potential meat count violations they may encounter in the upcoming year.
2. A new measuring board was designed and constructed for scallops which will allow faster and more accurate measurements of scallops at sea, as well as recording the data on both paper and magnetic media.
3. A study on the formation of daily growth rings in scallop spat was conducted in conjunction with J. Parsons and the results are presently being submitted for publication.
4. A design for the new histology laboratory was completed and a tender was prepared.
5. A small vessel safety course was organized through the local community college in order to train the users of the new Invertebrate workboat.

6. A volunteer logbook program was initiated with the small vessel fishery in southwestern New Brunswick. This has been very difficult to establish and will be developed further over time.

5. Goals/Expected Outputs for 1992:

1. Conduct scallop assessment surveys on the New Brunswick side of the Bay of Fundy concentrating on the upper Bay, Grand Manan and the Fundy Isles. Prepare CAFSAC documents for the annual meeting in March. (Robinson)
2. Continue with scallop spat project. Analyze one more year of settlement patterns over the grid system and choose reference spat stations for subsequent years. Continue with the study on the settlement phase of the larvae and postlarval survival. (Martin)
3. Redesign study to investigate selectivity of Digby scallop drags and assess immediate impacts on bottom. (Robinson)
4. Examine the relationship between environmental parameters and the settlement time and success in scallop spat. (Parsons)
5. Maintain effective communication linkages with scallop fishery representatives. (Robinson)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

1. A joint study on the validation of the occurrence of daily growth rings in the spat of sea scallops is being done with J. Parsons and J. Roff, from the University of Guelph, and M. Dadswell, from Acadia University.
2. Review of historical spawning trends in the sea scallop from the Passamaquoddy Bay area from 1978 to 1990 was completed. This work, involving L. Davidson and M. Lanteigne, from DFO, Moncton, Mr. J. Parsons, from the University of Guelph, and M. Dadswell, from Acadia University, has been accepted for publication in the journal Marine Ecology Progress Series.

ii. University Liaison -

1. Dr. John Himmelman, from Laval University, in Quebec, has a Ph.D. graduate student (Kevin Stokesbury) working in our lab on the behaviour of movement in the sea scallop.
2. Dr. Alan Fraser and his Ph.D. student (Eric DeGrace), from the University of Moncton, is involved in a study in one of our study areas in Passamaquoddy Bay to study seasonal changes in the mitochondrial DNA complement in the sea scallop.

3. See i) 1 & 2

iii. Communications -

1. CAFSAC scallop stock summary document for Grand Manan 1990-91.
2. Poster at the 8th International Pectinid Workshop; Cherbourg France. Robinson, S.M.C. and R.A. Chandler. A survey of growth rates in the giant scallop, Placopecten magellanicus, in the Bay of Fundy, using the RNA/DNA ratio technique.
3. Paper at the 8th International Pectinid Workshop; Cherbourg France. Parsons, G.J., S.M.C. Robinson, R.A. Chandler, L.A. Davidson, M. Lanteigne, M.J. Dadswell. Short- and long-term temporal and spatial patterns in the reproductive cycle in the giant scallop, Placopecten magellanicus.
4. Paper at the 8th International Pectinid Workshop; Cherbourg France. Robinson, S.M.C., J.D. Martin, R.A. Chandler, G. Parsons. Spat settlement patterns in the giant scallop Placopecten magellanicus, in Passamaquoddy Bay, New Brunswick, Canada.
5. Paper at the 1991 Annual Meeting of the National Shellfisheries Association in Portland, Maine. Robinson, S.M.C., J.D. Martin, R.A. Chandler, G. Parsons. Spatial patterns of spat settlement in the sea scallop, Placopecten magellanicus, compared to hydrographic conditions in Passamaquoddy Bay.
6. Video paper at the 1991 Annual Meeting of the National Shellfisheries Association in Portland, Maine. Robinson, S.M.C., J.D. Martin, R.A. Chandler, G. Parsons. A video assessment of a large mortality event in a population of the sea scallop, Placopecten magellanicus, in the Bay of Fundy, Canada.
7. Paper at the 1991 Annual Meeting of the National Shellfisheries Association in Portland, Maine. Parsons, G.J., S.M.C. Robinson, R.A. Chandler, L.A. Davidson, M. Lanteigne, M.J. Dadswell. Short- and long-term temporal and spatial patterns in the reproductive cycle in the giant scallop, Placopecten magellanicus, from Passamaquoddy Bay, New Brunswick, Canada.

iv. Contracts Administered -

1. Scallop spat sorting, measurement and analysis (\$1,875)

v. Other -

1. Attended 8th Pectinid Workshop in France, May 18 - June 1, 1991.
2. Attended National Shellfisheries Meeting in Portland, Maine, June 23-27, 1991.
3. Attended ISAC meetings in Halifax, September 27, 1991.
4. Attended CAFSAC Juvenile Workshop in Halifax, September 30, 1991.

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

Brief note to fishery officers in New Brunswick regarding average meat weights and counts in different areas of the Bay of Fundy.

8. Review and Evaluation:

A productive program directed at the regional scallop resource. Information gathered through graduate student research and collaboration with other research centres is complementing local research efforts and providing information that should lead to better understanding of scallop population dynamics.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 413

Section: Invertebrate Fisheries

Project Title: Lobster Stock Assessment (LFA's 35, 36 and 38)

Project Leader: Lawton, P.

Other Researchers: Robichaud, D.; Williamson, A.; Thorpe, B.

Work Activity: W.A.1.1.1.3

Key Words: lobster; assessments

1. Project Description:

This project is an ongoing function dealing with the monitoring of the lobster fishery in the Bay of Fundy (Lobster Fishing Areas 35, 36 and 38).

2. Long-Term Objectives:

Assess stocks and production of lobsters and make recommendations on the relative merits and potential effects of various management strategies (e.g., size limits, quotas, seasons, fishing effort, gear type); develop methods of analysis and theoretical models for the above; communicate results to the fishing industry, management bodies, and scientists, including primary scientific publications.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide resource assessment advice on the lobster fishery in the Bay of Fundy area as a contribution to the fishery management process. (Lawton)

During 1991, a major fishery management question was addressed, specifically the potential impact of a fishing season extension in LFA 36 on the lobster fishery in the Bay of Fundy. Lawton and Robichaud prepared background biological information and analyses on this topic. Lawton presented this material at four meetings with fishermen from LFA 35, 36 and 38, as well as contributing written material on scientific advice and jointly preparing a background paper on this issue with Fisheries and Habitat Management Branch. Consultations continued on lobster-aquaculture issues through inter-agency meetings, public meetings, and review of site applications.

2. Monitor the Bay of Fundy area lobster fishery through sampling program. (Robichaud)

Lobster Fishing Areas 35, 36, and 38 were monitored through at-sea sampling programs. Spring fishery samples were obtained from Alma (LFA 35), and Dipper Harbour (LFA 36). Fall fishery sampling was undertaken in Alma (LFA 35), Dipper Harbour and Beaver Harbour (LFA 36), North Head and Seal Cove (LFA 38).

3. To communicate results to the fishing industry through management advisory committee meetings, and production of a newsletter. (Lawton)

In addition to regular LFA Committee Meetings, P. Lawton was heavily involved in consultations with fishermen on season extension issues as described above. Due to a shortage in manpower and completing program priorities, a newsletter was not produced.

4. Assess the movement patterns of lobsters in LFA 36, particularly in the boundary area with LFA 35. Depending on funding levels, and manpower availability, this activity will be pursued either through a re-examination of historical data bases on lobster tag/recapture or with a focused tagging experiment. (Robichaud)

Due to a shortage in manpower and funding, no new tagging studies were initiated. However some historical data was reviewed, and all results pertaining to movement pattern in the boundary area with LFA 35 and 36, were included in advice presented to management on the season extension issue.

5. Prepare a technical report on the joint study (with industry) aimed at assessing the enhancement value of releasing pound-generated broodstock to LFA 38 fishing grounds. (Robichaud)

A first draft of a joint study (with industry), aimed at assessing the enhancement value of releasing pound-generated broodstock to LFA 38 fishing grounds, has been prepared and is ready for internal review. This will be reviewed for merit as a primary publication.

4. Additional Accomplishments:

1. Extensive input on scientific background and general editing of a comprehensive report on the history of the lobster fishery in LFA 36. (Lawton)

2. Helicopter survey undertaken in November 1991 to determine the extent of fishing activity in the area of the Wolves and offshore of the principal fishing areas in LFA 36 (Beaver Harbour, Dipper Harbour). (Lawton)
3. Historical data bases on lobster landings in the Atlantic Provinces compiled into manuscript form prior to the retirement of A. Williamson. (Williamson)
4. Presentation delivered to public meeting on Grand Manan on the environmental impacts of a major salmon aquaculture site on Grand Manan, as related to lobster populations, January 1991. (Lawton)
5. Participation in S.W. New Brunswick Aquaculture Working Group Meetings (DFO group; Lawton); assessment of specific aquaculture development proposals (part of DFO review process). (Lawton, Robichaud)

5. Goals/Expected Outputs for 1992:

1. Provide resource assessment advice on the lobster fishery in the Bay of Fundy area as a contribution to the fishery management process. (Lawton)
2. Monitor the Bay of Fundy area lobster fishery through sampling programs. (Robichaud)
3. To communicate results to the fishing industry through management advisory committee meetings. (Lawton)
4. Assess the movement patterns of lobsters in LFA 36, particularly in the boundary areas with LFA 35 by focusing on cross boundary movement. (Robichaud)
5. Prepare for primary publication the joint study (with industry) assessing the enhancement value of releasing pound-generated broodstock to LFA 38 fishing grounds. (Robichaud)
6. Publish a manuscript report on historical lobster landings for the Atlantic Provinces. (Lawton)

6. Background:

Highlights:

As predicted in the last review exercise, the group was tasked to provide biological advice on a traditional fisheries management concern, the open fishing season in LFA 36. The group contributed a significant portion of the background material used by the department in addressing this issue. Given the migratory nature of the lobster stock in the Bay of Fundy, the exercise required consideration of potential impacts on adjacent management areas (LFA's 35 and 38).

In June 1991 the group lost its technical support position following the retirement of A. Williamson. Over the last three years the group operating this project (and Project 414 which is principally a field research program), dealing with three lobster fishing areas, has been without technical support for nine months and has enjoyed only seven months of field technical support (through term contracts) over the period.

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

Gave several television, radio and newspaper interviews concerning the Bay of Fundy lobster fishery and lobster-aquaculture interactions. Participated in a total of seven meetings with Bay of Fundy lobster fishermen during the year, and three inter-agency meetings on lobster-aquaculture interaction. (Lawton)

iv. Contracts Administered -

Fall 1991 Fishery Monitoring in LFA's 36 and 38 (\$1.3K).

v. Other -

7. Publications:

i. Primary -

Robichaud D.A. and A. Campbell. 1991. Annual and seasonal size-frequency changes of trap-caught lobsters (*Homarus americanus*) in the Bay of Fundy. J. Northw. Atl. Fish. Sci. 11: 29-37.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project operates with suboptimal personnel and financial resources, yet it has produced timely advice to management and has involved area fishermen through formal and informal consultations and the development of an informative newsletter. Considerable, extra effort has been required to address the increasing problems of fisheries-aquaculture interaction in the Bay of Fundy area.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 414

Section: Invertebrate Fisheries

Project Title: Population Dynamics and Ecology of Bay of Fundy Lobsters

Project Leader: Lawton, P.

Other Researchers: Robichaud, D.

Work Activity: W.A.1.1.1.3

Key Words: lobster; assessment research; recruitment

1. Project Description:

This project is an ongoing function dealing with research into all aspects of the life history, ecology, and environment of juvenile and adult lobsters relevant in the short- and long-term to an understanding of natural and man-induced fluctuations in lobster stock size.

2. Long-Term Objectives:

Evaluate the impact of natural and man-induced factors on the ecology and productivity of lobster stocks by determining juvenile and adult lobster population parameters, such as growth, size-at-maturity, mortality, recruitment and migration, and how these vary temporally and spatially in relation to biotic and abiotic factors; apply existing population dynamics theory and approaches, and develop new analytical methods for the above studies; communicate the results to fishing industry, management bodies, and scientists.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue studies on juvenile lobsters in the Beaver Harbour area. Diving activities in 1991 will focus on refining our sampling techniques for recently settled lobsters, using air-lift samplers. (Lawton)

Our juvenile sampling technique using air-lift samplers was successful. For the first time in the Bay of Fundy, recently settled lobsters were captured on bottom in relatively high numbers. Fourth-stage lobster larvae were obtained off Beaver Harbour at the surface among seaweed clumps.

2. Complete construction of a laboratory facility for behavioural studies on juvenile lobsters. (Lawton)

Due to an extensive field schedule, effort on this objective was deferred until 1992.

3. Continue studies on the use of shallow water habitats off Grand Manan by mature lobsters, focusing on Flagg Cove and Whale Cove. Emphasis in 1991 will be placed on documenting the behaviour patterns of berried lobsters in relation to shelter fidelity, activity patterns, and population density. (Lawton)

Surveys on population densities and use of shallow water habitat by mature lobsters were undertaken in Flagg Cove during July, August and September, 1991. Experiments on behaviour patterns of berried lobsters in relation to shelter fidelity and activity patterns were undertaken using underwater lobster tagging techniques and lobster burrow identification. Due to overtime restrictions and boat time availability, no work was conducted in Whale Cove.

4. Prepare publications on: distribution of lobsters in inshore areas of the Fundy Isles Region in relation to salmon aquaculture development (technical report); seasonal use of inshore habitats on Grand Manan (primary publication). (Lawton, Robichaud)

Data on the distribution of lobsters in inshore areas of the Fundy Isles Region in relation to salmon aquaculture development has been analyzed. Due to an extensive field schedule, only preliminary data analysis has been completed on a manuscript describing the seasonal use of inshore habitats on Grand Manan. Portions of this research were presented at the National Shellfisheries Meeting, Portland, Maine, June, 1991.

5. Obtain further field experience in the use of ROV and side-scan sonar techniques for documenting the spatial patterning of nearshore lobster habitat. (Lawton)

There were insufficient resources within the project to charter commercial systems, and no systems were available within DFO.

4. Additional Accomplishments:

1. Through Canada - New Brunswick Cooperation Agreement funding (\$21K) survey work was conducted at several proposed aquaculture sites in the Fundy Isles Region by contract divers. The contract, administered by Lawton, provided information on lobster and scallop distribution in the vicinity of these sites from which recommendations were made to federal/provincial aquaculture advisory committees responsible for siting decisions.
  2. Two hundred and fifty laboratory-reared juvenile lobsters (6-35 mm CL) were marked and released by divers in Birch Cove, Passamaquoddy Bay, in order to evaluate the potential for enhancement of lobster populations in areas of optimum habitat, but low lobster densities. The area will be re-surveyed in 1992.
  3. In response to concerns from lobster fishermen and management over large incidental by-catch of lobsters by fish draggers off Grand Manan, a three-day survey using a rockhopper trawl and divers was completed in August 1991. Nine tows and four dives were made. All lobsters caught were tagged and released. The survey made use of a cruise originally scheduled on the J.L. Hart to evaluate ROV and side-scan sonar techniques. Based on survey results and consultation with fishermen, lobsters had migrated out of the area of dragging activity by the cruise date. Problems of gear conflict within the Bay of Fundy are apparently on the rise and are being monitored by the group.
  4. Presented one research paper at the Annual Meeting of the National Shellfisheries Association on the distribution of lobsters in shallow waters off Grand Manan (Lawton, Robichaud), and an interpretive video on our lobster field research. (Lawton)
5. Goals/Expected Outputs for 1992:
1. Continue studies on juvenile lobsters in the Beaver Harbour area. Diving activities in 1992 will expand the sampling coverage for recently settled lobsters, using air-lift samplers, to document spatial distribution patterns. (Lawton)
  2. Re-survey juvenile lobster release area at Birch Cove and continue to integrate the use of hatchery-reared juvenile lobsters, where practical, into field population studies on juvenile lobster ecology. (Lawton)
  3. Complete construction of a laboratory facility for behavioural studies on juvenile lobsters. (Lawton)
  4. Prepare publications on: distribution of lobsters in inshore areas of the Fundy Isles Region in relation to salmon aquaculture development (technical report); juvenile lobster distribution in relation to depth and substrate type in the Bay of Fundy (primary publication); seasonal use of inshore habitats on Grand Manan (primary publication). (Lawton, Robichaud)

6. Background:

Highlights:

Field research this year emphasised studies at particular locations on specific life-history stages, building on the synoptic surveys completed in earlier years. Particularly significant was the successful sampling of postlarval lobsters at relatively high density using suction sampling techniques. The group now has a substantial data set on juvenile lobster distribution in the Fundy Isles Region, which will be synthesized in the coming year, leading to further specific experimental studies. As noted under Project 413, inconsistency in technical support continues to be a major problem for this developing field research program. Considerable time was expended in this review year exploring a number of technician redeployment options and securing term technical support.

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

Contact was made with Dr. Robert Vadas, University of Maine at Orono, to discuss mutual research interests, resulting in planned collaborations, to begin in 1992. Contact was also made with Dr. Shirley Lim, Huntsman Marine Science Centre, to discuss a possible collaborative publication dealing with changes in benthos and lobster populations in the vicinity of a major salmon aquaculture site.

iii. Communications -

Article on lobster habitat ecology prepared for the 1990-91 Science Review.

iv. Contracts Administered -

Nova Divers, SCUBA diving, \$9.0K; boat charter (R. Carter), SCUBA diving support, 3.0K.

v. Other -

Attended Workshop on Environmental Aspects of Aquaculture, Bedford, March 1991 (Lawton); International Workshop on the Effects of Physical Disturbance on the Benthos, Bedford, May, 1991 (Lawton, Robichaud); Canadian Workshop on Juvenile Ecology and Fisheries, Halifax, October 1991 (Lawton). Provided peer reviews of proposals for NOAA Undersea Research Program (\$45K US); NSF (Biological Oceanography; \$221K US); NSERC (3 proposals; \$65K) (Lawton); 3 manuscripts were reviewed for primary publications (Lawton, Robichaud).

7. Publications:

## i. Primary -

Robichaud, D.A., R.W. Elner and R.F.J. Bailey. 1991. Differential selection of crab Chionoecetes opilio and Hyas spp. as prey by sympatric cod Gadus morhua and thorny skate Raja radiata. Fishery Bulletin 89: 669-680.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

Lawton, P. and D. A. Robichaud. 1991. Shallow water spawning and molting areas of American lobsters, Homarus americanus, off Grand Manan, Bay of Fundy, Canada. J. Shellfish Res. 10: 286. (Abstract)

Lawton, P. and K. Taylor. 1991. Lobsters, crabs, and videotapes. J. Shellfish Res. 10: 282. (Abstract)

Contributed major sections (7 p.) to a departmental background paper (29 pp.) on management of the Bay of Fundy lobster fishery for distribution to area fishermen as part of the department's review of a season extension request from LFA 36.

8. Review and Evaluation:

This project is seriously limited by a lack of trained field personnel for conduct of research, especially those aspects involving SCUBA for underwater research. In spite of this, good progress has been made on all goals set for the current year.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 415

Section: Invertebrate Fisheries

Project Title: Invertebrate Biology

Project Leader: Waddy, S.

Other Researchers: Aiken, D.

Work Activity: W.A.1.1.1.3

Key Words: lobster biology

1. Project Description:

Biological research on commercially important invertebrates in support of fisheries assessment with emphasis on growth, development, reproduction and behaviour and the way in which these are influenced by the environment. Provide advice on the biology, holding and transportation of lobsters and assistance to enforcement officers on regulatory matters.

2. Long-Term Objectives:

Obtain biological information on commercially important invertebrates and identify how environmental factors influence invertebrate biological cycles and recruitment success.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare and submit for publication an interpretive review paper on the role of temperature as the primary regulator of maturation and reproduction in American lobster stocks. (Waddy)

Manuscript is in press in the Proceedings of the ICES Symposium on Shellfish Life Histories.

2. Prepare and submit for primary publication a manuscript on the requirement for low winter temperature for successful and synchronized spawning in American lobsters. (Waddy)

Manuscript in press in the Canadian Journal of Fisheries and Aquatic Sciences.

3. Continue research on the environmental control of spawning in American lobsters. 1) define the change in the interaction of temperature and photoperiod that occurs at the winter solstice, and 2) assess the effect of low summer temperature on spawning in female lobsters. (Waddy)

Study 3.1 completed and manuscript in preparation; results will be presented at the annual meeting of the American Society of Zoologists in December. Study 3.2 was deferred until 1992 because of budget constraints and equipment problems.

4. Conduct a series of studies on the environmental requirements of the Anophrys-like parasite that has caused significant losses in the lobster holding industry. (Waddy)

Studies indicated that temperature conditions under which this parasite can survive and cause losses are quite different than originally thought. Although the parasite has always been associated with low temperature conditions, our studies demonstrated that it can survive, reproduce and cause mortalities at temperatures as high as 14C.

5. Complete a manual on systems, strategies and biological requirements for the lobster storage and shipment industry. (Young-Lai)

Mr. Young-Lai, who was responsible for this goal, has left the project and intends to complete it in his new assignment with PCS.

6. Complete the re-evaluation of size-at-maturity in lobsters from North Head, Grand Manan. (Waddy)

Considerable work done but due to financial constraints sufficient numbers of these very large lobsters could not be purchased to complete the project. However, results have confirmed that published results on size at maturity for this area are inaccurate. Some additional data are required before the study can be published in the primary literature.

7. Construct a new facility for experiments on juvenile lobsters and begin studies on environmental regulation of growth in juveniles. (Waddy)

Facility to rear juvenile lobsters under temperature and photoperiod conditions characteristic of nearshore Bay of Fundy conditions was completed. Studies will begin just as soon as lobsters are of

an adequate size.

8. Transfer scientific and technical information on lobster holding and biology to the industry, private sector and general public by providing information and advice through personal contacts, telephone communication, lectures, etc.

Responded to 207 written, personal and telephone requests for technical information on lobster biology and physiology, storage and shipment, holding systems, disease and general aquaculture. Clients included pound operators, fishermen and other industry people, entrepreneurs, consultants, researchers, lawyers, graduate students and the media.

9. Continue cooperative study with personnel in the Benthic Fisheries and Aquaculture Division, Halifax, to determine the size at maturity of lobsters from southwestern Nova Scotia. (Waddy)

Benthic Fisheries and Aquaculture (Halifax) decided not to continue with this project in 1991.

10. Develop a proposal to investigate the potential impact of global warming on basic biological processes (growth, reproduction) of marine invertebrates with demonstrated or potential commercial value.

Proposal developed.

#### 4. Additional Accomplishments:

1. Served as Chairman of the Regional Animal Care Committee. (Waddy)
2. Presented a paper at the annual meeting of the American Society of Zoologists on the role of darkness in regulating molt in larval American lobsters. (Waddy)
3. Participated in a cooperative study with Dr. Brian Tsukimura and Dr. David Borst on the diurnal fluctuation in methylarnesoate production in precovigerous female lobsters. (Waddy)
4. Designed and developed new tank design with internal feeding system for holding small lobsters for experimental work; made major renovations to the lobster research facility to make it more suitable for current studies. (Henderson)
5. Provided broodstock females and the technology for controlling egg and larval production to a commercial lobster culture facility in Utah. (Waddy)
6. Invited to present a plenary review at the Fourth International Symposium on Invertebrate Reproduction being held in 1992. (Waddy)
7. Invited to contribute two chapters on lobster biology to a book on the American lobster being edited by Dr. J. Factor, SUNY. (Waddy)
8. Reared over 700 juvenile lobsters to an age of one year for a cooperative field project on juvenile ecology with Peter Lawton. (Waddy)
9. Presented an invited lecture to a graduate student class at Louisiana State University. (Waddy)
10. Co-authored a primary publication (CJFAS) on the lobster nemertean. (Waddy)
11. Co-authored an invited review paper on crustacean molting and growth for Reviews in Aquatic Sciences. (Waddy)

#### 5. Goals/Expected Outputs for 1992:

1. Conduct research on the factors controlling recruitment in juvenile lobsters: (Waddy)
  - a) conduct a series of studies on the factors and biological mechanisms regulating molt synchrony and vertical migration in larval lobsters;
  - b) develop a stock of juvenile lobsters and determine whether responses of lab-reared juveniles are comparable to field-caught animals for experimental work (studies planned 1992/93 on behavior and ecology);
  - c) design and fabricate an experimental holding system for studies on pre-recruit lobsters;
  - d) continue studies on the biology of the ciliate Anophrys and its interaction with the lobster.
2. Conduct research on biological mechanisms and cycles that influence egg production, maturation, migration and behavior of the American lobster: (Waddy)
  - a) conduct a study to determine the influence of autumn and winter seawater temperatures on the success of egg production;
  - b) continue studies to define the complex seasonal temperature requirements for egg production;
  - c) continue studies on flexibility in mating strategies that enable lobsters to maximize their reproductive potential;
  - d) continue studies on male reproductive cycles and temporal variation in male potency;
  - e) continue work on the Bay of Fundy size at maturity study.
3. Communicate scientific and technical information on lobster biology: (Waddy)
  - a) prepare and deliver an invited plenary review at the Fourth International Symposium on Invertebrate Reproduction: "Controlling Reproduction in the American Lobster"; prepare manuscript for primary publication in Invertebrate Reproduction and Development;
  - b) prepare the first draft of two invited book chapters for a book on the American lobster being edited by Dr. Jan Factor, SUNY;
  - c) transfer technical information on lobster holding and biology to the industry, private sector and general public by providing information and advice through personal contacts, telephone communications, lectures, etc.;
  - d) complete and submit two manuscripts on lobster reproduction to CJFAS.

4. Serve on the Regional Animal Care Committee. (Waddy)

6. Background:

Highlights:

The completion and publication of two invited interpretive review chapters and a third review for the primary literature on various aspects of lobster biology and behavior was a highlight.

Selected Involvements:

i. Collaborative Research -

Conducting collaborative studies with Dr. Hans Laufer of the University of Connecticut, Drs. David Borst and Brian Tsukimura of Illinois State University and Dr. Jackie Vogel of the Marine Biological Laboratory, Woods Hole. Collaborative project on juvenile ecology with Peter Lawton.

ii. University Liaison -

One television, two radio and two newspaper interviews on lobster biology and disease, one weekly science briefing, four lectures to university and community college students and tours of the lobster research facility to more than 100 people.

iii. Communications -

One television, two radio and two newspaper interviews on lobster biology and disease, one weekly science briefing, four lectures to university and community college students and tours of the lobster research facility to more than 100 people.

iv. Contracts Administered -

v. Other -

External reviews on 11 manuscripts submitted for primary publication and edited 59 manuscripts for scientific and technical publications.

7. Publications:

i. Primary -

ii. Interpretive Scientific -

Waddy, S. L. and D. E. Aiken. 1991. Egg Production in the American lobster, Homarus americanus. In: Crustacean Issues 4, Crustacean Egg Production (A. Wenner and A. Kuris, eds.), p. 281-301. Balkema Press, Amsterdam.

Waddy, S. L. and D. E. Aiken. 1991. Mating and insemination in the American lobster, Homarus americanus. In: Crustacean Sexual Biology, p. 126-144. R.T. Bauer & J.W. Martin, eds., Columbia University Press, New York.

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

Waddy, S.L. 1991. The view from here. Bull. Aquacul. Assoc. Canada 91-3: 13.

Waddy, S.L. and D.E. Aiken. 1991. Scotophase regulation of the diel timing of the metamorphic molt in larval American lobsters, Homarus americanus. J. Shellfish Res. 10: 287. (abstract)

8. Review and Evaluation:

Research on biological cycles is becoming increasingly important as the probability of global warming increases. This project continues to establish mechanisms and define important biological relationships in the lobster; it would be useful to expand this work to include other commercially important marine invertebrates.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 416

Section: Invertebrate Fisheries

Project Title: Resource Potential of Underutilized Invertebrate Species

Project Leader: Robinson, S.; Lawton, P.

Other Researchers: Martin, J.D.; Robichaud, D.; Chandler, R.

Work Activity: W.A.1.1.1.3

Key Words: underutilized invertebrates; assessment research; ecology

1. Project Description:

Studies on growth, mortality, reproduction, ecology, and population structure of underutilized invertebrate species that have commercial fisheries potential in the Bay of Fundy.

2. Long-Term Objectives:

Obtain a thorough understanding of the biology, natural history, and population characteristics of underutilized Bay of Fundy invertebrates so that advice can be given for the prudent management of emergent fisheries.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Examine the development of sea urchin roe on a spatial and temporal basis at selected sites in the Fundy Isles area.

A study was funded through the Canada - New Brunswick Cooperation Agreement to study the seasonal development of sea urchin roe from February to the end of March.

2. Document the efficiency and impacts of sea urchin harvesting methodologies on the bottom substrate and fauna.

A small segment of the above study dealt with the evaluation of various types of fishing gears with regard to fishing efficiency and observed damage to the bottom at the time of harvest.

3. Record fishing location and effort in the periwinkle fishery via helicopter surveys and logbook analysis.

Due to a reduction in operating funds the helicopter survey program was put on hold for this year. However, contact with the industry was made and a few pickers agreed to fill out logs for us.

4. Initiate studies on the population dynamics of the green sea urchin and northern sea cucumber in Southwest New Brunswick to establish the biological rationale for sustained development of these fisheries. This project is contingent on additional A-base funding, targeted specifically at underutilized species development.

No funding for research on underutilized species was forthcoming. Research plans were put on hold until such time funds become available.

5. Maintain an overview on underutilized invertebrate species in the Bay of Fundy area and communicate results to industry through meetings, workshops, and newsletters.

A meeting was held with the local southwestern New Brunswick sea urchin fishing industry in March and a summary of the research was reported.

4. Additional Accomplishments:

1. A limited survey of sea cucumber distribution was undertaken in March 1991 through the Canada - New Brunswick Cooperation Agreement.
2. A logbook was designed for sea urchin diving and dragging fisheries in New Brunswick and Nova Scotia.
3. The sea urchin management plan was reviewed in conjunction with management and licensing in Halifax.
4. A survey of periwinkle size distribution during the late winter was conducted in conjunction with the industry in March 1991 throughout the Quoddy Region.

5. Goals/Expected Outputs for 1992:

1. Continue with research on the green sea urchin in southwestern New Brunswick pertaining to stock characteristics and fishing impacts. This project is entirely contingent on additional funding being available.
2. Analyze logbooks submitted by fishermen for the 1991-92 sea urchin fishing season. (Robinson)
3. Maintain an overview on underutilized species in the Bay of Fundy area and communicate results to industry through meetings, workshops, and newsletters.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

Underutilized invertebrate fisheries resources are of increasing importance to the Bay of Fundy area, however, funding for resource surveys has been restricted. Some exploratory work on sea urchins has been carried out. An information base on several species is slowly being developed. The project leaders have made every effort to advance the biological understanding of those species now fished under experimental permit.

**ST. ANDREWS BIOLOGICAL STATION**

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 500

Section: St. Andrews Biological Station

Project Title: Administration and Support Services

Project Leader: Waiwood, B.

Other Researchers: Best, B.; Carney, C.; Hurley, J.; Polar, S.

Work Activity: W.A.1.1.0.0

Key Words: administration; technical support services

1. Project Description:

Provide scientific support to meet the requirements of scientists and technicians at the Biological Station. In particular, provide the following for all research projects at St. Andrews: word processing and secretarial service, small vessels, electronic services, and implementation of the Management Services functions delegated to the Station (Material Management, Facilities, Library, Central Registry, Photography, and Drafting) and to accommodate the Atlantic Reference Centre operation.

2. Long-Term Objectives:

Continue to provide efficient and up-to-date scientific support services in the areas noted above to all Station users requiring these services. Also, continue to provide a smooth working relationship at the Station level between the Management Services and Science Sectors.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Provided efficient scientific support services for researchers within the resources provided and effectively managed the ARC. The mechanical technologist position was not staffed so that all work requests were either contracted out or not delivered; this will continue to be the case. The loss of the Director's secretary position (from AIFD) during the downsizing exercise resulted in an overall loss of secretarial services to all scientific staff. This cannot continue without causing extremely detrimental effects on scientific staff morale and productivity; it will have significant impact on the new Director. Facilities have been improved by the construction of a dedicated common use Histology Laboratory. Construction was started on the Sample Storage Building in October 1991, with completion slated for April 1992; this will allow relocation of all Atlantic Reference Centre material, the Templeman collection from Newfoundland and Biological Station specimens under one roof.

4. Additional Accomplishments:

The access road to the Station was repaired over a 100-ft section; the condition of the road in general, however, continues to be a problem. Three new vehicles were acquired under the Departmental vehicle acquisition program.

5. Goals/Expected Outputs for 1992:

During 1992, the plan is to provide efficient scientific support services for scientific staff within the resources provided; the latter phrase is becoming increasingly important in light of PY and operating fund cutbacks. Secretarial support for the Director is a necessity and must be addressed within the re-organization of the Biological Station. Within the delegated Management Services functions, staffing of the vacant position for an electrician will enhance the in-house capability to maintain facilities.

6. Background:

## Highlights:

Scientific support services has historically encompassed a wide range of functions from mechanical and electronic technologies to word processing and secretarial services. Within the restrictions of PY allocations, the services have been reduced both in areas covered and level provided. The use of computer technology in word processing and secretarial services has brought those functions completely up to date. Electronic technology service continues to suffer from a lack of 'state-of-the-art' monitoring equipment.

The operation of Management Services functions on a delegated basis under the Station's scientific support group continues to operate reasonably effectively. An area of concern is the process of communication and rationale for funding level - especially in the Library.

## Selected Involvements:

1. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Within the limits of the budget and reduced manpower, overall objectives were generally achieved.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 510

Section: St. Andrews Biological Station

Project Title: Computer Centre

Project Leader: Wainwood, B.

Other Researchers: Ballis, S.; Fawkes, S.; Hatt, B.

Work Activity: WAA11.1.5.0

Key Words: computer centre; data processing; statistical advice

1. Project Description:

Provides computing power, programming and system support (both hardware and software), and Data Entry services to scientific staff in the Biological Sciences Branch.

2. Long-Term Objectives:

Ensure that the Biological Station computing system is upgraded and enhanced to keep pace with technological developments relevant to fisheries research.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Continued to maintain the Computing System at optimum efficiency by monitoring and tuning system parameters. The loss of the statistician in June 1991 has removed the statistical advice and expertise capability from the Station. The major accomplishment was the installation of an Ethernet LAN, to be completed in 1992. Linkage to the Regional network is still being implemented. Full presentation graphics capability has been provided by acquisition of LAN server versions of Harvard Graphics and Sigma Plot for the VAX 6210. The provision of a computer output room was the first step towards implementing the recommendations of the RCMP security report.

4. Additional Accomplishments:

Word processing equipment was updated and participation in Word Processing Special Interest Group by secretaries and WP personnel has proven to be a valuable training tool.

Data Entry functions have been upgraded by acquisition of Entry Point 90 software.

Acquisition of the Archive SQL package for ORACLE has streamlined that function.

5. Goals/Expected Outputs for 1992:

Improve the operation of the VAX 6210 and distributed network environment by implementation of performance evaluation systems and a satisfactory backup package.

Linkage to all Regional networks with transparent communication processes should be completed with the cooperation of Scientific Computing Services Division.

Evaluation of total computing services at the Biological Station will be carried out to assess the options for the planned upgrade by BSB.

6. Background:Highlights:

Computer services have been provided to all research projects/researchers at the St. Andrews Biological Station since 1960. The loss of the statistician has ended the statistical advice capability. Acquisition of the VAX 6210 has placed the computer centre in the position of having hardware for which dedicated VAX software is no longer fiscally feasible.

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The computer centre continued to provide computing services to the scientific staff. However, there is a need to formally identify the Regional policy with regard to computing services; with a policy in place, the format and development of the Station computer centre could be planned and resources utilized more efficiently. The current move from central units to distributed networks of PCs has created an extra workload of PC troubleshooting without the manpower needed; if SCSD is to be re-organized, the need for extra staff in St. Andrews should be recognized.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 520

Section: St. Andrews Biological Station

Project Title: S/V J.L. HART

Project Leader: Waiwood, B.

Other Researchers: Lumsden, D.; Banks, M.; Haughn, D.; Pitre, R.

Work Activity: W.A.1.1.0.0

Key Words: research vessel

1. Project Description:

Operate the S/V J.L. HART to serve the Station's stock assessment associated biological research programs in the most effective manner. The HART conducts a wide range of work, i.e. midwater and bottom trawling, scalloping, water and bottom sampling, as well as utilizing specialized gear over an area from St. Andrews to Georges Bank.

2. Long-Term Objectives:

Continue providing acceptable research vessel service for St. Andrews Biological Station programs as well as those from Halifax and the Gulf Region; ensure that scheduled requirements are met and the cost effectiveness of the vessel is maintained.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

For 1991/92 season, the J.L. HART spent 79 days at sea of the 144 originally scheduled. Major gear box failure was the reason for loss of time; a total of 55 days were used for turnaround, gear maintenance and repair work. The vessel is still without a functioning gear box due to the imposition of the spending freeze. A total of seven cruises had to be cancelled. The work carried out during the 10 cruises completed encompassed Bay of Fundy scallop assessment surveys (4), groundfish juvenile assessments (3), lobster assessment (1), Bay of Fundy phytotoxin survey (1) and live haddock collection (1).

4. Additional Accomplishments:

The level of overtime funding for the crew caused problems for scientific staff in terms of their ability to conduct surveys in the most logical manner. The crew should be commended for their cooperation and competency in ensuring surveys were successful.

5. Goals/Expected Outputs for 1992:

The initial schedule for 1992 calls for 118 sea days over 12 cruises. As long as the gear box is repaired during April, there should be no difficulty in meeting these requirements. For the first time, the vessel will be utilized in surveillance operations off SW Nova Scotia in November.

6. Background:

## Highlights:

Fisheries research vessel services have been provided at the Biological Station for all research programs for many years. The cutback from year-round to seasonal operation has reduced requirements over the past five years.

The lack of overtime funding during the 1991 season restricted ability to fulfil scientific program needs. As a result, requests for scheduled time have decreased for the 1992 season. The opportunity to utilize the vessel for surveillance work counteracts this effect.

## Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

There was significant loss of vessel days during 1991 due to breakdown of the gear shaft. This has been a recurring problem which has received only patchwork repairs historically. There needs to be an identified budget for repair/maintenance of the J.L. HART. While this disrupted the schedule, those cruises which were completed produced praise for the excellent performance of the crew. The captain should also be commended for the improved appearance of the vessel.

The cooperation of Marine Services Division staff, MSB, in facilitating equipment repair/replacement and an early refit during the off-season is appreciated.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 530

Section: St. Andrews Biological Station

Project Title: S/V PANDALUS III

Project Leader: Waiwood, B.

Other Researchers: Guptill, Capt. F.; Miner, Capt. W.

Work Activity: W.A.1.1.0.0

Key Words: research vessel

1. Project Description:

Operate the S/V PANDALUS III primarily as a day boat to serve the Station's resource and stock assessment and associated biological research programs in the most effective manner. The PANDALUS is required to carry out a wide range of work, i.e. bottom trawling, scalloping, water and bottom sampling, as well as utilizing specialized gear in the Passamaquoddy Bay area.

2. Long-Term Objectives:

Continue providing an acceptable level of research vessel service for St. Andrews Biological Station programs; ensure that scheduled requirements are met and the cost effectiveness of the vessel maintained.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

The PANDALUS III provided 191 sea days of operation during 1991/92. This level of service was provided in the absence of the Captain on work-related disability, by utilizing the Captain of the J.L. HART on a term basis. The operation of the boat with only one PY continues to hamper the ability to provide trawling without supplementation by scientific programs. The level of utilization continued to be very heavy, leaving minimal time for maintenance. The lack of overtime budget did hamper the ability of the vessel to conduct work at locations distant from home port. All programs at the Biological Station utilized the PANDALUS with greatest use by scallop, phytoplankton, benthic sampling and aquaculture programs.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

Output for 1992/93 should be at approximately the same level; there may be a slight drop in utilization when the GEMMA is launched (AIFD work boat). Operation of the PANDALUS with only one crew continues to be a concern on the basis of safety. Vessel requirements for trawling will not be met without participation by scientific staff or the provision of extra crew by program money. The lack of an overtime budget will continue to hamper away-port operation.

6. Background:

## Highlights:

Basic fisheries research vessel services have been provided at the Biological Station for all research programs for many years. With program reductions over the past couple of years, the current level of requirements has been reduced. The reduction of staff on the PANDALUS from 2 to 1 PY limits her fishing capabilities. Fishing requirements have been generally met with supplementary resources from scientific program budgets.

## Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Scheduled vessel requirements were met successfully and some of the inshore work originally scheduled for the J.L. HART was covered by the PANDALUS where possible. Restriction to 8 h operation days has not always been satisfactory for scientific requirements, a realistic overtime budget is a necessity.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Aquaculture and Invertebrate Fisheries

Project No.: 540

Section: St. Andrews Biological Station

Project Title: Atlantic Reference Centre

Project Leader: Cook, R. (Scientific Authority); Sulak, K. (Huntsman Marine Science Centre)

Other Researchers: Pohle, G.; Van Guelpen, L.; Hogans, W.; Lim, S.

Work Activity: W.A.1.1.1.1; W.A.1.1.1.2; W.A.1.1.1.3; W.A.1.1.1.6; W.A.1.1.1.7

Key Words: taxonomy; systematics; identification; collection; zoogeography; functional morphology; life history; population biology; parasitology; environmental baseline and monitoring

1. Project Description:

The Atlantic Reference Centre (ARC) provides taxonomic and ecological expertise centered on an extensive reference collection of aquatic organisms from the Atlantic Canada region. The ARC functions to maintain, expand, document and manage the reference collection; provide identification services for DFO scientists; prepare appropriate taxonomic guides; collaborate with DFO investigations in appropriate areas of ARC staff expertise; promote and facilitate collection-based research by visiting investigators. The ARC is a joint project of DFO Scotia-Fundy Region and the Huntsman Marine Science Centre. In addition to core DFO and HMSC support, considerable supplementary contract and grant support contributes substantially to overall project funding.

2. Long-Term Objectives:

Maintain and expand the ARC reference collection of preserved aquatic biota that is comprehensively representative of the fauna of the region of Atlantic Canada. Develop and maintain a highly trained scientific and technical staff able to provide service primarily in taxonomic identification, and in other areas including environmental baseline and monitoring studies, population biology studies, larval and juvenile rearing work, and parasitology. Publish a continuing series of technical guides aimed at facilitating field and laboratory identification of taxonomically troublesome taxa of marine fishes and invertebrates. Provide technical training in taxonomic identification and methodology of sampling, preserving, and processing biological specimens. Provide public advisory service with respect to the regional fauna in terms of identity and life history of marine organisms.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

This project was not listed as a separate project in previous PREP documents. Operating costs were included within Project No. 500, but no goals/expected outputs were given for 1991. Accomplishments in 1991 are listed below:

## 1. Train DFO staff in identification and preparation of biological specimens.

ARC technical staff were trained in identification of fish eggs and larvae (Van Guelpen), and zooplankton (Pohle), to maintain and upgrade the level of competence for DFO service work. Training was also performed and on a separate contract basis for a DFO Newfoundland ichthyoplankton technician.

## 2. Prepare identification leaflets for either 'ARC Species ID Leaflet' series or 'Canadian Technical Report for Fisheries and Aquatic Sciences series'.

Completed are final ink drawings for the eelpout leaflet, and verified preliminary pencil drawings for the skate and flatfish leaflets. Literature research and specimen study is complete for the eelpout leaflet, ongoing for the other two leaflets.

## 3. Catalog and curate collection of aquatic biota.

The Newfoundland collection has been organized for re-conditioning. Two significant collections of large pelagic fishes were received from the international observer program (BIO, Halliday); about 75 percent of specimens from the first shipment have been identified and transferred into alcohol tank storage. A major shipment of midwater fishes was received from Halliday for incorporation into the ARC collection. Reconditioning of the ARC habitat collection of larval fishes and the DFO larval lobster collection continued. Routine cataloging of existing and incoming material continued. Loans of preserved specimens were processed to DFO and university scientists to facilitate taxonomic research. Compiled a list of parasitic copepods in the collection of the ARC.

## 4. Provide taxonomic services and advice.

Participated in various DFO cruises to: assist in experimental deep-water fisheries trials; advise on deep-water invertebrate identifications; assist in Nova Scotia tuna tagging cruises. Provided advice on microphotography, cataloging, multivariate statistical analyses, and on collecting, cataloging,

preserving, sorting, and identifying of fish and zooplankton to DFO scientists, graduate students, and International Observers. Identified and/or verified identifications of fish, parasitic helminths, disease agents of marine fish collected in DFO cruises.

5. Facilitate move of collection into new storage building.

Organization and packing of the ARC collection to facilitate transfer to and re-organization in the new collection building.

4. Additional Accomplishments:

Fish identification services provided to other DFO regions and universities: Bosse (DFO Quebec), Courtenay (DFO Gulf), Atkinson (DFO Newfoundland), Fortier (Laval Univ.), Methven (Memorial Univ.). Presentation of ARC facilities and capabilities given to St. Lawrence University.

5. Goals/Expected Outputs for 1992:

1. Continue identification, verification, re-conditioning, cataloging and computer documentation of backlog and new biological material.
2. Continue processing, documentation, and incorporation of DFO Newfoundland (Templeman collection).
3. Continue organization and packing of ARC collection in preparation for move into new collection building in 1992.
4. Continue computerization of the collection data base using the MUSE collection inventory software system.
5. Continue to research missing locality data and gaps in locality data necessary for documentation of the ARC collection.
6. Complete and print ID leaflets on eelpouts and flounders; continue work on skate ID leaflet.
7. Initiate planning for thorough revision of faunal guide: 'Preliminary Guide to the Marine Invertebrates of Passamaquoddy Bay'. (Lim, Pohle, Gratto)
8. Complete major faunal manuscript on taxonomic composition of the aquatic fauna of Kouchibouguac National Park and the adjacent watershed.

6. Background:

Highlights:

Over its short history (1984-present) the ARC has developed substantially in terms of staff, facilities, external support and capabilities. It has also expanded the breadth of its activities and expertise. Currently, the core staff of four is supplemented by two additional Ph.D. biologists, and a technical assistant staff (biologists, technicians, computer operator, natural history artist) numbering 19.

Selected Involvements:

- i. Collaborative Research -
  - 1) Hogans collaborated with Porter on tuna tagging, with Peterson on striped bass culture.
  - 2) Pohle collaborated with Halliday on unexploited deep-water fishery resources (resulting in a DFO Technical Report).
  - 3) Sulak is involved in long-term collaboration with Halliday, Themelis (Halliday graduate student) and Gartner (Florida Institute of Marine Research) on the taxonomy and distribution of midwater fishes of the Scotian slope.
- ii. University Liaison -
  - 1) Sulak is collaborating with Ross (University of North Carolina, Wilmington) in submersible investigations of the demersal bottomfish fauna of the Hatteras continental slope; with Shcherbachev (Institute of Oceanology, Moscow) on taxonomy and distribution of deep-sea fishes; with Crabtree (Florida Institute of Marine Research) on systematics and morphology of deep-sea fishes.
  - 2) Lim is collaborating with Diaz (Virginia Institute of Marine Science) on analyses of benthic infaunal populations; with Findlay (University of Maine) on sediment bacterial biomass in relation to salmon aquaculture.
  - 3) Hogans is collaborating with the New Brunswick Department of Natural Resources and the Canadian Wildlife Service in seaduck population census work.
  - 4) Fisheries biostatistics course (IDRC/Lim) taught at Freshwater Fisheries Research Institute, Wuxi, China.
  - 5) Selected lectures by ARC staff to HMSC university courses and New Brunswick Community College aquaculture technician program.
  - 6) Seminar lectures by Pohle and Lim to University of New Brunswick graduate marine science course.

- 7) Sulak and Pohle have associate appointments at Canadian universities and are serving on graduate student committees. One graduate student (Marques) is a resident intern at the ARC.

iii. Communications -

- 1) Sulak was appointed to the Canadian National Committee, Scientific Committee on Oceanographic Research, and attended the annual meeting held at Winnipeg.
- 2) Lim and Gratto participated in a benthic workshop (in relation to effects of salmon aquaculture) held at the Darling Marine Center, Walpole, Maine.
- 3) Pohle and Hogans prepared a synopsis of environmental study needs for presentation by Dr. Allen, HMSC, to the St. Croix International Waterway Commission.
- 4) Lim presented paper on the environmental impact of salmon cage farming to the 19th Annual Marine Benthic Meeting, Williamsburg, Virginia, and the 8th Annual Meeting of the Aquaculture Association of Canada, St. Andrews.
- 5) Sulak present a paper on demersal slopefish communities to the U.S. Department of the Interior, Minerals Management Service, Fourth Information Transfer Meeting, in Wilmington, North Carolina.

iv. Contracts Administered -

a. DFO Supporting Region Contracts Undertaken - FY 1991-1992 -

- 1) Sorting and identification of Scotia-Fundy ichthyoplankton from Georges Bank. (Melvin)
- 2) Nova Scotia bluefin tuna population analysis. (Porter)
- 3) Sorting and identification of ichthyoplankton from Bay of Fundy herring program. (Stephenson, Melvin)

b. Supplementary Contracts Undertaken - FY 1991-1992 -

- 1) Several contracts for sorting and identification of zooplankton and ichthyoplankton - NOAA/NMFS Northeast Fisheries Center, Sandy Hook Laboratory; Florida Department of Natural Resources; DFO Newfoundland.
- 2) Effects of salmon aquaculture on benthic infaunal communities in Passamaquoddy Bay - New Brunswick Department of Fisheries and Aquaculture.
- 3) Kouchibouguac National Park incidental fisheries species population analysis - Parks Canada.
- 4) Striped bass culture pilot project - New Brunswick Department of Fisheries and Aquaculture, plus anticipated industrial support.
- 5) Interannual and spatial variability of zooplankton (copepods) abundance and composition in the southern Gulf of St. Lawrence - DFO Quebec.

v. Other -

- 1) Analysis of zoogeography and life history patterns for deep-living Atlantic bottomfishes - NSERC Operating Grant. (Sulak)
- 2) Systematics and evolution of Crustacea based on comparative functional morphology of setae and associated components - NSERC Operating Grant. (Pohle)
- 3) Demersal deep-sea bottomfish population investigations, Hatteras continental slope - U.S. National Undersea Research Program.
- 4) Influence of trematode parasite load on growth, behavior and avian predation of Macoma balthica (Mollusca, Tellinidae) in Hudson Bay - NSERC Operating Grant. (Lim, pending)

7. Publications:

i. Primary -

Lim, S.S.L. and R.H. Green. 1991. The relationship between parasite load, crawling behaviour and growth rate of Macoma balthica (L.) (Mollusca, Pelecypoda) from Hudson Bay (Canada). *Can. J. Zool.* 69: 2202-2208.

Markle, D.F. and J.E. Olney. 1991. Systematics of pearlfishes (Pisces: Carapidae). *Bull. Mar. Sci.* 47(2): 269-410.

ii. Interpretive Scientific -

Sulak, K.J. 1991. Notacanthidae, Halosauridae, Aulopidae, Synodontidae, Chlorophthalmidae. *In: Checklist of the Fishes of the Eastern Tropical Atlantic (CLOPETA)* (J.-C. Quero, editor). UNESCO Publication.

iii. Scientific and Technical -

Lim, S. 1991. The environmental impact of salmon cage farming on the benthic community in the Bay of Fundy (Canada). *Bull. Aquacult. Assoc. Can.* 91-3: 102-104.

Pohle, G. 1991. A guide to decapod Crustacea from the Canadian Atlantic: Anomura and Brachyura.

Can. Tech. Rep. Fish. and Aquat. Sci. No. 1771: iv + 30 pp.

Porter, J. and W.E. Hogans. 1991. A mark-recapture experiment on bluefin tuna (Thunnus thynnus L.) from the Browns-Georges banks region of the Canadian Atlantic. International Commission for the Conservation of Atlantic Tunas, Col. Vol. Sci. Pap., Madrid 35: 253-256.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project provides an essential taxonomic identification service to fisheries researchers in the Scotia-Fundy Region, as well as to other regions of the Atlantic coast. In addition, ARC is making significant contributions in ecosystem studies, notably in effects of aquaculture on the benthic environment.

**BIOLOGICAL OCEANOGRAPHY DIVISION**

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 600

Section:

Project Title: Bio-Optical Properties of Pelagic Oceans

Project Leader: Platt, T.

Other Researchers:

Work Activity: W.A.1.1.1.8

Key Words: biological oceanography; phytoplankton; primary production

1. Project Description:

Understand the transmission of visible light through the ocean, in particular the way it is affected by organisms. The largest variable component of light absorption in the ocean is that due to the pigments in phytoplankton. In turn, phytoplankton need light to grow by photosynthesis. The project aims at describing all these relationships in mathematical terms for a range of oceanographic regimes. This is important to the development of remote sensing technology and to optical communication underwater. Collaborative research is conducted with the Department of National Defence.

2. Long-Term Objectives:

Determine the optical characteristics of picoplankton suspensions including: optical absorption in relation to pigment compositions; the action spectrum for picoplankton cultures; the vertical profile of available light in the sea; vertical attenuation coefficients with respect to wavelength. Compare results with the vertical structure of plankton communities; the photoadaptive properties of phytoplankton under various conditions of turbulent mixing; the wavelength-dependence of photosynthesis for size fractionated field populations. Define algorithms for determining phytoplankton productivity from remotely sensed data. Apply research results from the above studies toward determining their significance for optical communication and understanding the trophic role of picoplankton; calculating quantum yields and upper limits of biological activity in the ocean.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Consolidation by regional application of role of remote sensing in biological oceanography. Report completed and published using North Atlantic as type region.

4. Additional Accomplishments:

Served as Co-Chairman, Productivity of Global Ocean Project, International Space Year.

5. Goals/Expected Outputs for 1992:

1. Major cruise to North Atlantic for optics and biology.
2. Report on remote sensing for computation of ocean primary production.

6. Background:

Highlights:

Selected Involvements:

## i. Collaborative Research -

European Space Agency under International Space Year.  
Joint Research Centre, Ispra (Italy) under International Space Year.  
DND Wakehamier under Task #: 13/1-1990 (91911).

## ii. University Liaison -

Through Canadian Committee for NSERC, with Dr. Sathyendranath (Dalhousie University).

## iii. Communications -

Many public lectures.

## iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Platt, T., C. Caverhill and S. Sathyendranath. 1991. Basin-scale estimates of oceanic primary production by remote sensing: the North Atlantic. *Journal of Geophysical Research* 96(C8): 15,147-15,159.

Platt, T. and S. Sathyendranath. 1991. Biological production models as elements of coupled, atmosphere-ocean models for climate research. *J. Geophys. Res.* 96(C2): 2585-2592.

Sathyendranath, S., A.D. Gouveia, S.R. Shetye, P. Ravindran and T. Platt. 1991. Biological control of surface temperature in the Arabian Sea. *Nature* 349(6304): 54-56.

Sathyendranath, S. and T. Platt. 1991. Angular distribution of the submarine light field: modification by multiple scattering. *Proc. R. Soc. Lond. A.* 433: 287-297.

Sathyendranath, S., T. Platt, E.P.W. Horne, W.G. Harrison, O. Ulloa, R. Outerbridge and N. Hoepffner. 1991. Estimation of new production in the ocean by compound remote sensing. *Nature* 353: 129-133.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Optical techniques are of ever-increasing importance in biological oceanography and this project is essential if the Division is to keep abreast of developments in the field. A strong optical program is fundamental to the optimal use of remotely-sensed data on ocean colour. This is an area in which Canada is playing a leading role.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 602

Section:

Project Title: Respiration, Nutrient Uptake, Regeneration of Natural Plankton Populations

Project Leader: Harrison, W.

Other Researchers: Platt, T.

Work Activity: WAA11.1.1.8

Key Words: phytoplankton; biological oceanography; primary production

1. Project Description:

Dissolved nutrients, along with temperature and light, are the environmental properties critical in determining the levels of primary production in the oceans. In most of the world's oceans, nutrients (and specifically nitrogen) are thought to be the primary limiting factor and are the key to understanding the biogeochemical cycles of most other elements dissolved in seawater. This project investigates the distribution, uptake, and regeneration of nutrients and the role they play in the primary production of the oceans. This has relevance to fisheries problems and to the longer-term global problems of ocean circulation and climate.

2. Long-Term Objectives:

Determine the role dissolved nutrients play in the distribution, biomass, and production of marine phytoplankton; identify and quantify the sources of nutrients available to phytoplankton, and especially the role microplankton play in the regeneration of nutrients from organic matter in seawater; determine how much primary production is supported by 'new' nutrients (i.e., from external sources) and how this varies in space and time.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue analysis and interpretation of data collected during 1990 JGOFS cruise.

Analysis of JGOFS/90 cruise data near completion. Results from JGOFS/89 cruise submitted (two manuscripts) for publication in the *Deep-Sea Research* special JGOFS volume. Additional results from the JGOFS/90 and JGOFS/91 cruise submitted for publication in *Nature*.

2. Implement field program for testing and evaluating newly procured sea-going mass spectrometer and new instrumentation/techniques for ultra low-level nitrogen analysis in seawater.

Tests carried out during the spring 1991 JGOFS cruise to the NW Atlantic and during the fall CSS Dawson cruise to the Gulf of Maine were highly successful. Performance of the mass spectrometer exceeded our expectations with regard to reliability and instrument sensitivity. Low-level analyses of nitrate also successful; plans are underway to test a new technique (based on derivative fluorescence) for low-level ammonium analysis.

4. Additional Accomplishments:

1. Published manuscript (with co-author) on the analysis of carbon, nitrogen, phosphorus and silicon in marine particulates.
2. Published two manuscripts (with co-authors) on particulate organic matter and nitrogen cycling in the equatorial Pacific.
3. Published manuscript (with co-authors) on seasonal nitrogen dynamics in the subtropical Pacific.
4. Published manuscript (with co-author) on new production in polar waters.
5. Published manuscript (with co-authors) estimating new production on Georges Bank by compound remote sensing.
6. Published review article (with co-author) on nutrient effects on primary production in polar waters.
7. Published review article on nutrient regeneration in the world's oceans.
8. Participated in AGU-sponsored workshop on analysis and characterization of marine particles in January.
9. Participated in AESS-sponsored technical meeting on natural sources and sinks of greenhouse gases in February.

10. Participated in 37th Brookhaven Symposium in Biology in June.
11. Participated in annual ASLO conference in June.
12. Participated in PERD (4.8 Generic Environment) panel meeting in July.
13. Participated in 4th International Phycological Congress in August.
14. Participated in Georges Bank workshop in October.

5. Goals/Expected Outputs for 1992:

1. Continue analysis and interpretation of data collected during 1990 and 1991 JGOFS cruises.
2. Implement field program for 4th JGOFS cruise to the subtropical eastern Atlantic.
3. Implement new collaborative studies with Chile (IFOP) as part of the JGOFS Eastern Boundary Current Study.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

1. Final (wrap-up) manuscript of collaborative study with U.S. scientists on NSF-funded VERTEX program published (Contact: Dr. G.A. Knauer, NSTL, Mississippi, USA).
2. Several manuscripts in preparation from collaborative studies on Georges Bank (participants: BIO-Biological Sciences, Physical-Chemical Sciences Branches, St. Andrews and Dalhousie University).
3. Collaborative studies with Chile (IFOP) on the JGOFS Eastern Boundary Current Study will commence with cruise work off the coast of Chile in January, 1992.

ii. University Liaison -

Honorary Research Associate with the Departments of Oceanography and Biology at Dalhousie; supervision of graduate student research.

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Harrison, W.G., L.R. Harris, D.M. Karl, G.A. Knauer and D.G. Redalje. 1991. Nitrogen dynamics at the VERTEX time-series site. *Deep-Sea Research*, In press.

Harrison, W.G. and E.J.H. Head. 1991. Particulate C, N, P and Si analysis at the Bedford Institute of Oceanography, Canada, pp. 69-70, In: D.C. Hurd and D.W. Spencer (eds.), *Marine Particles: Analysis and Characterization. Geophysical Monograph 63*, American Geophysical Union, Wash., D.C.

Pena, M. Angelica, M.R. Lewis and W.G. Harrison. 1991. Particulate organic matter and chlorophyll in the surface layer of the equatorial Pacific Ocean along 135W. *Deep-Sea Research*, In press.

Pena, M. Angelica, W.G. Harrison and M.R. Lewis. 1991. New production in the central Equatorial Pacific. *Marine Ecology - Progress Series*, In press.

Sathyendranath, S., T. Platt, E.P.W. Horne, W.G. Harrison, O. Ulloa, R. Outerbridge and N. Hoepffner. 1991. Estimation of new production in the ocean by compound remote sensing. *Nature*, 353: 129-133.

Smith, W.O., Jr. and W.G. Harrison. 1991. New production in polar regions: the role of environmental controls. *Deep-Sea Research*, In press.

ii. Interpretive Scientific -

Karl, D.M., W.G. Harrison, J. Dore and others. 1991. Chapter 3. Major Bioelements, pp. 33-42, In: D.C. Hurd and D.W. Spencer (eds.), *Marine Particles: Analysis and Characterization. Geophysical Monograph 63*, American Geophysical Union, Wash., D.C.

Harrison, W.G. 1991. Regeneration of nutrients, In press, In: P. Falkowski (ed.), *Primary Productivity and Biogeochemical Cycles in the Sea. Brookhaven Symposium in Biology No. 37*, Plenum

Press, New York.

Harrison, W.G. and G.F. Cota. 1991. Primary production in polar waters: relation to nutrient availability, In press, In: E. Sakshaug, C.E. Hopkins and N.A. Oritsland (eds.), Proceedings from the Pro Mare Symposium on Polar Marine Ecology, Trondheim, 12-16 May 1990. *Polar Research* 10.

iii. Scientific and Technical -

Legendre, L., K. Juniper, D. Booth, A. Cembella, Y. de Lafontaine, J. Gagne, W. Harrison, S. Roy, B. Saint-Marie, A. Sinclair, R. Trites and A. Vezina. 1991. Report of the workshop on biological oceanography, pp. 23-30. In: J.-C. Therriault (ed.), *The Gulf of St. Lawrence: Small Ocean or Big Estuary?* *Can. Spec. Publ. Fish. Aquat. Sci.* 113.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Study of nitrogen cycle is central to the Division's program in climate change. This work is of major importance. It is also one of the most fruitful programs in the Division.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 603

Section:

Project Title: Physical Oceanography of Selected Features in Connection with Marine Ecological Studies

Project Leader: Horne, E.

Other Researchers:

Work Activity: W.A.1.1.1.8

Key Words: biological oceanography; primary production

1. Project Description:

The principle goal of this project is to understand how turbulence affects biological production. Analyses are conducted on turbulence data from the Arctic, where the driving force is buoyancy due to melting ice, and from Georges Bank where the driving forces are tidal. Georges Bank data show a large variation of turbulence levels with the stage of the tide and we plan to compare our measurements to those from theoretical models. A new problem that has been studied is the measurement of underwater light spectra and how this affects primary production. This project collaborates with J. Loder, N. Oakey, and K. Drinkwater from PCSB on an ongoing basis.

2. Long-Term Objectives:

Understand how: turbulence levels on Georges Bank change over a tidal cycle; the high productivity levels on Georges Bank are maintained; ice influences turbulence levels in the Arctic; turbulence affects phytoplankton production; and, to predict oceanic primary production from light spectra measurements.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete a paper on 1990 JGOFS data showing zooplankton grazing on chlorophyll profile.

The completion of this paper was delayed until data from an optical zooplankton counter was obtained, at the same time as the fluorometer was collecting data, to confirm that the fluorometer spikes were actually zooplankton. This data was collected on the 1991 JGOFS cruise and is presently being analyzed.

2. Complete a paper on 1988 Georges Bank data showing the detailed structure of currents and hydrography on the northern side of Georges Bank.

This paper was completed and has been submitted to JGR.

3. Test BUD and the spectral irradiance meters at sea.

This was accomplished on the JGOFS, WOCE and a PCS Branch instrument testing cruise on Dawson. After about two weeks into this trip we were able to get the CCD spectral radiometer working during the WOCE cruise and collected high quality optical measurements for the rest of the trip in a variety of water types. The instrument works better than expected and has enough sensitivity and resolution to easily resolve the upwelling peak in chlorophyll a. Large changes in reflectance are measured with biomass and modelling efforts are now underway to see if the observed results follow conventional theory. There is a suggestion in the data of addition peaks, caused by other pigments, but the sensitivity is not great enough to fully resolve them. Plans are underway to increase the sensitivity of the instrument by, upgrading to a more modern CCD and modifying how we subtract the dark signal so that we can integrate longer and hence get more sensitivity. In addition we collected growth rate, HPLC and spectro fluorometric data to help interpret the optical data. This data should help a great deal in fulfilling our contractual obligations to DND to understand the influence of phytoplankton in the transmission of light in the ocean. On the Dawson cruise a few minor problems were identified with BUD and when these are corrected it will become an operational instrument for the 1992 field season.

4. Continue preparation of an atlas of hydrographic data from 1988 Georges Bank data.

Data processing is progressing nicely and the atlas should be finished in 1992.

4. Additional Accomplishments:

To aid Dr. Head in interpreting some HPLC data from the 1990 JGOFS cruise some Batfish data collected during that trip was analyzed. This showed what appeared to be a jet of water from the eastern basin of the Atlantic passing through our experimental sight. Furthermore the fluorometer data from the Batfish showed high levels of chlorophyll extending to greater depths at the jet. This, along with the paths of the sediment traps, suggested that the jet or front was also a convergence. This

interpretation helped to clear up some puzzling results from the pigment data and has been written up and submitted to *Deep Sea Research*.

5. Goals/Expected Outputs for 1992:

1. Complete a paper on the 1990 JGOFS data showing zooplankton grazing on chlorophyll profile.
2. Analyze and write up the 1991 optical data collected during the WOCE cruise.
3. Upgrade the spectral irradiance meter to use a thinned MPP CCD and to subtract the dark current in the instrument and then build two instruments to go on BUD.
4. Use BUD operationally at sea with a full suite of sensors.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

The cosine lens designed by Dr. Powell of NRC was built and tested. The response is very nearly cosine and our measurement technique is being modified so that the small error can be measured. Once this is done Dr. Powell can prescribe a variable density coating for one of the lens surfaces to correct the error.

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

The UP contract to Seimac to construct BUD was completed and the instrument delivered. The instrument was tested in October and only a few minor problems detected. BUD will become an operational instrument during the 1992 field season.

v. Other -

7. Publications:

i. Primary -

Loder, J.W. and E.P.W. Horne. 1991. Skew eddy fluxes as signatures of nonlinear tidal current interactions, with application to Georges Bank. *Atmosphere-Ocean*. 29: 517-546.

Sathyendranath, S., T. Platt, E.P.W. Horne, W.G. Harrison, O. Ulloa, R. Outerbridge and N. Hoepffner. 1991. Estimation of new production in the ocean by compound remote sensing. *Nature* 353: 129-133.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project represents essential physical oceanographic support to the Division's work. At the same time, it is breaking new ground in instrumentation. It represents an excellent example of scientific collaboration between Branches.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 604

Section:

Project Title: Physiology of Marine Microorganisms

Project Leader: Li, W.

Other Researchers: Dickie, P.

Work Activity: W.A.1.1.1.8

Key Words: phytoplankton; bacteria; biological oceanography

1. Project Description:

Photosynthetic (i.e., algae and cyanobacteria) and heterotrophic (bacterial) microorganisms are abundant and ubiquitous in marine plankton assemblages. They account for a large proportion of energy and material transfer in pelagic systems. Contemporary discussions about the "microbial loop" of marine food webs rely on an understanding of these microorganisms. This project utilizes the methods of experimental physiological ecology to study the influence of environmental factors, both abiotic and biotic, on the abundance and metabolic rates of bacteria and phytoplankton in the ocean.

2. Long-Term Objectives:

This project aims to determine the abundance, distribution, and physiological activity of phytoplankton and bacterioplankton in the ocean. Attempts will be made to study the short and long-term metabolic changes in these microorganisms in response to environmental changes. These results will delineate the role played by microbial primary and secondary producers in marine food webs.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Conduct new work investigating the factors influencing rates of phytoplankton and bacterioplankton growth. (Li, Dickie)

New data concerning the distribution, abundance and metabolic activities of phytoplankton and bacterioplankton were collected on the 1991 JGOFS study. A limited time-series sampling programme was initiated in the Bedford Basin to study microbial dynamics. New initiatives were undertaken to investigate the possibility of studying phytoplankton production by flow cytometric sorting of radioactively labelled cells and by flow cytometric analysis of DCMU-enhanced chlorophyll a fluorescence.

2. Continue examination of samples acquired from previous work. (Li, Dickie)

Almost all of the samples collected during the 1990 field studies have been examined. Work is ongoing to process field samples collected during 1991.

3. Continue analysis of acquired data in preparation for publication. (Li)

A total of eight papers are at various stages of the publication procedure (3 published, 3 in press, 2 in review). The most notable of these are the several papers describing work from the 1989 JGOFS pilot study.

4. Additional Accomplishments:

1. Member of the organising committee for the 1992 ICES Symposium on measuring primary production in the ocean. (Li)
2. Vice-chairman of the Bigelow Laboratory (USA) Flow Cytometer Advisory Committee. (Li)
3. Member of JGOFS expert group on "Bacterial Biomass and Production".
4. Supervision 2 PhD students and 1 participant in the Co-operative Education Training Programme. (Li)
5. Award of Distinction (1991) from Jandel Scientific Corporation. (Li)

5. Goals/Expected Outputs for 1992:

1. Conduct new work investigating the factors influencing rates of phytoplankton and bacterioplankton growth. (Li, Dickie)
2. Continue examination of samples acquired from previous work. (Li, Dickie)

3. Continue analysis of acquired data in preparation for publication. (Li)
4. Organise an ICES Symposium on the Measurement of Primary Production in the Sea. (Li)

#### 6. Background:

##### Highlights:

##### Selected Involvements:

##### i. Collaborative Research -

Participation in international JGOFS activities. Collaborative experiments with Dalhousie University (Halifax), University of Malaga (Spain) and University of Oregon (USA).

##### ii. University Liaison -

Member of graduate student thesis committees.

##### iii. Communications -

Presentation at annual meeting of American Society of Limnology and Oceanography.

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Li, W.K.W. and P.M. Dickie. 1991. Light and dark carbon-14 uptake in dimly-lit oligotrophic waters: relation to bacterial activity. *Journal of Plankton Research* 13 (Supplement): 29-44.

Li, W.K.W. and P.M. Dickie. 1991. Relationship between the number of dividing and non-dividing cells of cyanobacteria in North Atlantic picoplankton. *Journal of Phycology* 27:559-565.

Li, W.K.W., P.M. Dickie, B.D. Irwin, and A.M. Wood. 1991. Biomass of bacteria, cyanobacteria, prochlorophytes and photosynthetic eukaryotes in the Sargasso Sea. *Deep-Sea Research*: In press.

Li, W.K.W., M.R. Lewis, and A. Lister. 1991. Flow cytometric detection of prochlorophytes and cyanobacteria in the Gulf of Policastro, Italy. *Archiv für Hydrobiologie*: In press.

Li, W.K.W., P.M. Dickie, W.G. Harrison, and B.D. Irwin. 1991. Biomass and production of bacteria and phytoplankton during the spring bloom in the western North Atlantic Ocean. *Deep-Sea Research*: Submitted.

Harrison, W.G., E.J.H. Head, E.P.E. Horne, B. Irwin, W.K.K. Li, A.R. Longhurst, M. Paranjape, and T. Platt. 1991. The western North Atlantic bloom experiment. *Deep-Sea Research*: Submitted.

Longhurst, A.R., I. Koike, W.K.W. Li, J. Rodriguez, P. Dickie, P. Kepkay, F. Partensky, B. Bautista, J. Ruiz, M. Wells, and D. Bird. 1991. Sub-micron particulates in North-West Atlantic shelf water. *Deep-Sea Research*: In press.

Subba Rao, D.V., F. Partensky, G. Wohlgeschaffen and W.K.W. Li. 1991. Flow cytometric and microscopic study of gametogenesis in *Nitzschia pungens* (Bacillariophyceae) a toxic, bloom-forming marine diatom. *Journal of Phycology* 27: 21-26.

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

##### iv. Popular and Miscellaneous -

Li, W.K.W., M.R. Lewis and A. Lister. 1991. Picoplankton in the Gulf of Policastro. *Signal & Noise* 4:3.

Li, W.K.W. 1991. Creating maps with SigmaPlot® Jandel Scientific Newsletter 5:2.

#### 8. Review and Evaluation:

This project represents fundamental research of high quality that has immediate application in the area of climate change.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 607

Section:

Project Title: Carbon Dioxide and Climate: Biogeochemical Cycles in the Ocean

Project Leader: Platt, T.

Other Researchers: Harrison, W.

Work Activity: W.A.1.1.1.8

Key Words: climate changes; phytoplankton; primary production; biological oceanography

1. Project Description:

Carbon dioxide diffuses readily between ocean and atmosphere and is the primary substrate for nutrition and growth of phytoplankton. On a global scale, phytoplankton use  $5 \times 10^{10}$  tons  $\text{CO}_2$  annually, or more than the entire input of  $\text{CO}_2$  into the atmosphere from burning of fossil fuels. The increasing input of  $\text{CO}_2$  into the atmosphere from fossil fuel consumption is believed to lead to significant changes in the earth's climate before the end of this century. This project examines the role of the oceanic biota as a possible sink for a significant fraction of the increased atmospheric  $\text{CO}_2$ . It is relevant to the aims of the Joint Global Ocean Flux Study (JGOFS).

2. Long-Term Objectives:

Determine by direct measurement, in a broad range of ocean environments: (a) the proportion of total primary production that sinks out of the photic zone; and (b) the vertical flux of nitrate into the photic zone. Construct and analyze ecological models for interpretation of results.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Further JGOFS field work, N. Atlantic.  
Commissioned two major field programs on CSS Hudson.
2. Participation in scientific leadership, JGOFS.  
Served as Chairman, JGOFS International.

4. Additional Accomplishments:

Many interviews with the press, radio and television.

5. Goals/Expected Outputs for 1992:

1. Further JGOFS field work, N. Atlantic.
2. Participation in scientific leadership, JGOFS.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

## 7. Publications:

### i. Primary -

Platt, T., P. Jauhari and S. Sathyendranath. 1991. Oceanic microflora and the global carbon cycle. *CO<sub>2</sub> Climate Report*, Environment Canada. 91-1.

Platt, T., P. Jauhari and S. Sathyendranath. The importance and measurement of new production. In: P. Falkowski (ed.). *Primary Production and Biogeochemical Cycles in the Sea*. Plenum Publishing.

Quifones, R.A. and T. Platt. 1991. The relationship between the f-ratio and the P:R ratio in the pelagic ecosystem. *Limnol. Oceanogr.* 36(1): 211-213.

### ii. Interpretive Scientific -

### iii. Scientific and Technical -

### iv. Popular and Miscellaneous -

## 8. Review and Evaluation:

This project encompasses much of the Division's work in the area of climate change, and is fundamental to the Divisional participation in JGOFS. It is a project that provides a thread of coordination for many of the Divisional scientists.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 608

Section:

Project Title: Analysis of Pelagic Ecosystem Structure

Project Leader: Longhurst, A.

Other Researchers:

Work Activity: W.A.1.1.1.8

Key Words: modelling; zooplankton; secondary production; biological oceanography

1. Project Description:

Investigations of how simplified quantitative models of marine ecosystems can be formulated although such ecosystems comprise a greater diversity of basic life forms - with a greater diversity of interactions - than any terrestrial ecosystem, which are frequently the basis for holistic ecological models, and for much of theoretical ecology. See note in Section 6 below.

2. Long-Term Objectives:

Contribute to the formulation of holistic models of marine ecosystems, which are essential for the development of predictive ecology as an element in marine science.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Continue to accumulate information on prey/predator ratios in marine pelagic ecosystems.

This work was completed and incorporated in a lecture given at the ASLO Special Symposium on iron limitation in the ocean (see below). The general conclusions already reported were not altered by the expansion of the data base, and no further work is planned on 'prey'/'predator' size relationships. The fundamental conclusions from the study are that the ratio is much more variable than usually assumed, being constrained only for protistan biota, where the architectural limitations of a single cell contain both 'prey' and 'predator' more closely than among the metazoans. It is found that in all major taxa there are exceptions to the 'big eats smaller' rule, and 'big eats exceedingly small' feeding relations also occur in all major taxa. Both of these findings have implications for how we must view the flow of material and energy along biological particle size spectra.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

As time and opportunity avails, continue work on plankton diversity/water column stability, and on the effects of viscosity on the structure of the biological particle size spectrum, probably by soliciting cooperation by a physicist specialising in viscosity problems.

6. Background:

Highlights:

Note: This project represents my general participation as a zooplankton and fisheries ecologist in work of the Biological Oceanography Division, outside my researches related especially to the vertical structuring of the pelagic ecosystem and global carbon flux.

Selected Involvements:

## i. Collaborative Research -

Data set for Indian oil sardine and its environment was supplied to scientists at CRODT, Dakar, Senegal for use in models relating wind-stress to clupeid recruitment.

## ii. University Liaison -

## iii. Communications -

Globe and Mail science correspondent was briefed on the study by myself and Prof. Wooster (U. Washington) on the role of distantly-forced upwelling on the abundance of oil sardines off India.

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This work provides essential background to the bio-optical research in project No. 600.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 609

Section:

Project Title: Carbon and Nitrogen Utilization by Zooplankton and Factors Controlling Secondary Production

Project Leader: Conover, R.

Other Researchers:

Work Activity: W.A.1.1.1.8

Key Words: secondary production; zooplankton; biological oceanography

1. Project Description:

It is theoretically possible to estimate the \*P/B\* ratio from information about ingestion, respiration and excretion of zooplankton, and this has been modelled on several occasions using allometric relationships between metabolic rate and size of the organism. Two approaches have been taken: 1) the search for "indicators", such as key enzymes of intermediary metabolism, or, in the case of feeding by herbivores, the accumulation of chlorophyll-derived pigments in the body; and 2) the use of *in situ* metabolic chambers which capture natural populations of organisms in a presumably stress-free way to actually measure metabolic rates in the field.

2. Long-Term Objectives:

Develop a methodology for estimating "instantaneous" production rate for pelagic animals by development of biochemical and physiological indices of zooplankton activity pertaining to metabolism and growth; development of *in situ* metabolic chambers to measure metabolism and plankton activity directly in the field.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

If the opportunity arises and sufficient resources are available, we may be able to examine the usefulness of egg production as an index of secondary production on the Scotian Shelf or elsewhere. However, as we plan to initiate a new project for winter research in the arctic at this time, I do not anticipate much progress on Project No. 609 within the next fiscal year.

Field and laboratory data from a six-month study of reproduction in relation to nutritional state in *Calanus hyperboreus*, which was begun in Resolute in March 1989 and continued at both BIO and then back at Resolute, was used to prepare a paper called "Can copepods be iteroparous?" given at the summer ASLO meetings held in Halifax in June of this year. The answer to the question is almost certainly that they can. However there are several additional implications from this study. The loss of weight during reproduction is largely due to wax ester conversion directly to reproductive products and to metabolic energy required to make this conversion, because females do not feed appreciably during late winter and early spring when spawning occurs. Also because it is relatively easy to determine the weight of wax ester in individual females as they mature, one can predict their total fecundity. Second following a period of conditioning of several months, the copepods became well conditioned to their restricted laboratory environment and converted natural particulate matter from water collected near Resolute to wax ester with high efficiency. Growth rates were about 1% higher daily than "degrowth" rates associated with reproduction. The experiments suggest that comparable estimates of feeding and growth for natural populations can be obtained from conditioned animals raised on natural food at concentrations comparable to those encountered by the animals in nature.

4. Additional Accomplishments:

*In situ* studies on the feeding of medusae from Bedford Basin carried out with Sophie Matsakis, a visitor from France, were incorporated into her Ph.D. thesis and are now also in print. Similar techniques were used in a M.Sc. thesis by Tim Siferd on the nutritional biology of the arctic ctenophore *Mertensia ovum* (Dalhousie 1990). We are presently in the process of preparing some of his observations for publication. One joint paper has been submitted and a second is in preparation.

5. Goals/Expected Outputs for 1992:

Assuming that there will be money for arctic research (see Project No. 624), we will attempt to use "conditioned" animals in grazing experiments to examine some of the factors that affect the loss of chlorophyll-derived pigment during gut passage (see also Project No. 613). The best opportunity to do this in the coming year will probably be during the cruise of the MV Arctic to Northwater, but we will try similar experiments in the late summer/fall at Resolute.

6. Background:

**Highlights:**

The ASLO paper on potential iteroparity in northern long-lived zooplankton has been mentioned above.

**Selected Involvements:**

## i. Collaborative Research -

## ii. University Liaison -

I continue to serve on the committees of several Dalhousie graduate student and have been supervising three. One, Ding Wei successfully defended his M. Sc. thesis "Effects of Suspended Sediment on the Growth and Feeding Behaviour of the Juvenile Sea Scallop *Placopecten magellanicus* (Gmelin)" in June of this year.

I am still Liaison Officer for a Science Subvention Project to Dr. J.C.L. Wright in support of graduate student Tony Windust in the department of biology. His thesis is concerned with the effects of domoic acid on copepods. This fall I served as a "guinea pig" for several journalism students at Mount Saint Vincent University during an APICS conference on science communication to the public.

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

**7. Publications:**

## i. Primary -

Matsakis, S. and R.J. Conover. 1991. Abundance and feeding of medusae and their potential impact as predators on other zooplankton in Bedford Basin (Nova Scotia, Canada) during spring. *Can. J. Fish. Aquat. Sci.* 48: 1419-1430.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

This project is being assigned relatively low priority at present.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 611

Section:

Project Title: Secondary Production and the Dynamic Distribution of Micronekton in the Scotian Shelf

Project Leader: Sameoto, D.

Other Researchers: Kennedy, M.

Work Activity: W.A.1.1.1.8

Key Words: acoustics; secondary production; zooplankton; larvae; biological oceanography

1. Project Description:

The influence of the physical oceanography and the bottom topography on secondary production and community structure is the main focus of this project. High resolution sampling, both vertical and geographic, of the zooplankton and fish communities provides detailed information on species distribution and interactions, including the role of biological and physical factors.

2. Long-Term Objectives:

Produce a model for the secondary production of the major species that incorporates temporal changes due to advection and mixing of the different water masses on the shelf. Determine the influence of shelf and slope water beyond the shelfbreak on the biomass, species composition, and production of zooplankton on the NE Nova Scotia Shelf at different seasons measured over a period of three consecutive years. Study the feeding dynamics of micronekton and fish in the shelf basins and canyons along the shelfbreak.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete the data analysis of the acoustic/light experiments on the euphausiids and write a manuscript.
2. Study the abundance and distribution of euphausiids on the Nova Scotia Shelf to determine the influence of the Nova Scotia current on their population dynamics.

4. Additional Accomplishments:

Completed a successful experiment testing the use of video as an instrument for estimating the distribution and abundance of krill and gelatinous zooplankton.

5. Goals/Expected Outputs for 1992:

1. Study seasonal changes in the zooplankton community and biomass in deep basins on the SW Scotian Shelf and in the Gulf of Maine and relate biological changes in the physical environment. This will be done using new *in situ* sampling methods providing long term time series information.
2. Start field testing the new multi-frequency acoustic sampling instrument.

6. Background:

## Highlights:

1. The experiments using light mounted on the BIONESS reduced sampler avoidance of krill thereby making it possible for the first time to accurately relate the net biomass estimates with the estimates from acoustic data through new acoustic models we have developed.
2. Completed the manuscript on the effect of light on net avoidance by krill and developed a new acoustic model for estimating krill abundance.
3. Completed a manuscript dealing with the effect on zooplankton production and biomass of the Nova Scotia Current. This is now in press.

## Selected Involvements:

## i. Collaborative Research -

Collaborative research with Dr. Herman and Dr. Cochrane continues to be extremely successful in developing the moored *in situ* optical plankton counter and the multi-frequency acoustic system and in the study of *C. finmarchicus* and *Meganycthiphanes norvegica* populations as part of GLOBEC in the Gulf of Maine.

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This is an important research program in the fishery context. It is being pursued vigorously, and is yielding excellent results. A good example of collaboration with Physical and Chemical Sciences Branch.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 612

Section:

Project Title: Biological Stratification in the Ocean and Global Carbon Flux

Project Leader: Longhurst, A.

Other Researchers:

Work Activity: W.A.1.1.1.8

Key Words: climate changes; phytoplankton; primary production; biological oceanography

1. Project Description:

Investigations of the biological processes driven by the physical and chemical stratification of the upper ocean which are a major factor in the global production of plants and animals in the pelagic ecosystem, and in determining the rate of survival of fish larvae.

2. Long-Term Objectives:

Contribute to understanding of trophic relations of pelagic organisms, including fish by analysis of the ordered spatial relations of biota, especially in the vertically layered shelf and ocean ecosystems, and contribute to measurement and understanding of global carbon fluxes.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete a paper, the drafting of which has begun, describing the populations of 'Coulter' particles along a meridional section in the North Atlantic from 32-47°N. This will demonstrate and interpret the change in size-structure of particles which occurs abruptly below the thermocline, and the vertical distribution of sub-micron particles. The relationship between particle populations and other biological and chemical parameters of the profiles will be explored further than has been done for the general paper to be presented to the JGOFS symposium in 1990.

There has been limited progress in completing such a draft on the JGOFS 1989-90 MULTISIZER particle spectrum work because additional data was collected during the April 1991 JGOFS voyage and unexpected commitments (see comments on ISY study below) have intervened. Nevertheless, some work has been done towards completing this work and only minor additional data collection at sea is envisaged.

2. Exploit our ability to detect sub-micron particles in seawater with a Coulter Multisizer, and develop techniques for more routinely quantifying the population.

The MULTISIZER work during the 1991 JGOFS voyage was concentrated on obtaining profiles of sub-micron particles in the open ocean, to extend our knowledge of their global distribution. Previously, measurements had only been made in neritic waters, and in the high latitude NW Pacific. A 200m depth section was obtained from the continental shelf off SW Nova Scotia out to the oligotrophic central Sargasso Sea. Counts were lower by almost an order of magnitude than had previously been found in neritic water off Nova Scotia and Japan, but the anticipated gradients (decreasing numbers with depth down the profiles and decreasing numbers with distance offshore) were clearly identified in the data. This work was done simultaneously with similar work (by Koike, U. Tokyo) in the eastern Pacific, in open ocean environments. Paradoxically, though the two instruments (BIO, MULTISIZER and U. Tokyo, ELZONE) calibrated very satisfactorily in trials held last year at BIO, the open ocean data do not appear to be compatible. The reason for this is now under investigation.

3. Complete the study of seasonal vertical migration by North Atlantic copepods of mass occurrence at OWS 'INDIA' and interpret the data in terms of active vertical flux of carbon and nitrogen by seasonal migration. This will complete the first phase of the general study of active vertical CN flux that had previously concentrated only on the consequence of diel fluxes. Write up results as paper for the primary literature.

The full data set for 4 species of copepods for 5 years at OWS INDIA from weekly LHPH hauls (40-50 depths to 500m) was obtained and analyzed and the study of active carbon flux caused by seasonal ontogenetic migration was completed. It was concluded that though only about 25% of deep overwintering biomass survives until the spring, the loss of carbon at depth is not significant in global terms compared with other vertical carbon fluxes. This is because the high latitude plankton, where seasonal migration occurs, forms a small percentage of the global plankton biomass. The study has been completed to first draft status and is currently being reviewed by the co-author at the Plymouth Marine Laboratory. This probably completes this study, intended to quantify the active flux of carbon and nitrogen mediated by diel and seasonal vertical migrations of zooplankters. It has been shown that active flux of carbon and nitrogen down from the mixed layer through the pycnocline by interzonal diel migrants is of sufficient magnitude that it should be considered in global models of vertical carbon flux in the ocean. The final component was to determine that the flux caused by

seasonal migrants is a small number.

4. Possibly it will be useful, if time permits, to expand globally the North Atlantic Secchi depth analysis.

The entire global Secchi data base has been brought into microcomputer format and a first analysis has been done to extend the Atlantic analysis performed last year. The size of the data base proves, however, to be misleading. A very large percentage of all data ever collected anywhere is for the North Pacific, in the region of the Japanese islands. The Secchi observation is routinely performed and reported aboard Japanese fishing boats and training ships.

#### 4. Additional Accomplishments:

1. In relation to the computation of global oceanic primary production, required as part of Project #607 (Platt) work was undertaken (using experience gained within the current project) towards the definition of biogeochemical provinces in the ocean. This work is partially funded by Canadian and European Space Agencies. Within such provinces it will be necessary to assume that the (seasonal) profiles of chlorophyll are predictable within acceptable limits so that algorithms computing water column primary production can be parameterized for each region/season. This is an essential step in the use of satellite colour imagery to compute seasonal/annual uptake of carbon by phytoplankton. A first sketch of a set of about 50 regions globally, wherein we might rationally expect homogeneity obtain has been completed. Detailed work on the North Atlantic has now been undertaken, parallel with detailed work on the Arabian Sea undertaken by John Brock, post-doctoral fellow supported under the same project.
2. Response was made to a farrago inappropriately published in the otherwise peer-reviewed journal *Global Biogeochemical Cycles* by Wally Broecker of Lamont-Dougherty, in which he stated that geochemical modelling alone was urgent in relation to the climate change problem and that the marine biosphere was uninvolved at the scales of concern. Though so badly crafted as to be essentially unanswerable, this paper required answering, and my response was one among several, orchestrated to contain the damage already done.

#### 5. Goals/Expected Outputs for 1992:

1. Complete analysis of biogeochemical regions as outlined above, and participate in computation of Atlantic primary production.
2. Complete study of North Atlantic particle spectra from MUTISIZER data.
3. Participate, as appropriate, in the Division's 1992 JGOFS voyage.
4. If time avails, formulate (with Dr. Glen Harrison) a simple compartment model of global carbon flux to examine the consequences of uncertainties concerning input functions and internal parameters present, but usually unstated, in current version of predictive geochemical models. User-friendly microcomputer system simulation software will be used for this.

#### 6. Background:

##### Highlights:

The work undertaken within this project comprises part of the Division's research pertinent to Canadian involvement in the international JGOFS experiment, and is intended to expose the role of zooplankton in the transfer of organic material (and hence anthropogenic carbon from atmospheric CO<sub>2</sub>) from the surface waters of the ocean to the deep ocean carbon sink. Concentration is on observational techniques and subsequent budgeting, and is intended to complement the experimental/physiological research undertaken by others.

##### Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

#### 7. Publications:

- i. Primary -

Longhurst, A.R. (with Koike, Li, Rodriguez, Dickie, Kepkay, Partensky, Bautista, Ruiz, Wells, and Bird) 1991 Sub-micron particles in northwest Atlantic shelf water. *Deep-Sea Research* 38 (12) [rapid response paper]

- ii. Interpretive Scientific -

Longhurst, A.R. 1991 Role of the marine biosphere in the global carbon cycle. *Limnology and Oceanography* 36 (8) [special issue on iron limitation of phytoplankton growth]

Longhurst, A.R. A response to Broecker's charges. *Global Biogeochemical Cycles* 5(4)

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This work is fundamental to the national contribution to JGOFS and it continues to make excellent progress.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 613

Section:

Project Title: Nutrition and Biochemistry in Marine Zooplankton

Project Leader: Head, E.

Other Researchers: Harris, L.

Work Activity: W.A.1.1.1.8

Key Words: zooplankton; secondary production; nutrition; biological oceanography

1. Project Description:

In this project the biochemical composition of zooplankton food sources (i.e., particulate material from various depths of the water column) is assessed. Comparison of the compositions of the food with faeces using conservative tracers and measurement of respiration and ammonia excretion rates enable calculation of assimilation efficiencies for the various biochemical components. This information will lead to an understanding of zooplankton nutrition and how it varies under different environmental conditions.

2. Long-Term Objectives:

Investigate the relationship between zooplankton food and faecal pellet composition, both *in vivo* and *in vitro*.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Completion of sample and data analysis for material collected on the 1990 JGOFS cruise. (Head)

Analysis of samples collected on the 1990 JGOFS cruise has been completed. Data analysis has mostly been completed and one manuscript based on data from this cruise has been submitted for publication (see Section 4).

2. Preparation of a manuscript on the role of copepods in carbon flux in the 1989 JGOFS.

A manuscript has been prepared, in conjunction with other members of the group, which synthesizes the results of the 1989 JGOFS cruise and includes the role of copepods in carbon flux. It has been submitted for publication in an edition of *Deep-Sea Research* which will be devoted to work related to JGOFS and the "North Atlantic Bloom Experiment".

Manuscript submitted:

Harrison, W.G., E.J.H. Head, E.P.W. Horne, B. Irwin, W.K.W. Li, A.R. Longhurst, M. Paranjape and T. Platt. The Western North Atlantic Bloom Experiment. *Deep-Sea Res.* (submitted)

3. Participation in field work as part of continuing JGOFS studies, either to study carbon flux due to copepod defecation or to measure pigments in particulate profiles and/or copepod faecal pellets.

Experiments were undertaken on the 1991 JGOFS cruise to evaluate the role of copepods in carbon flux. Sample analysis is well advanced. Experiments were also undertaken to investigate pigment breakdown during copepod feeding (a) to identify pigments in faecal pellets (by HPLC analysis) and (b) to calculate pigment transformation budgets. Analysis of samples arising from these studies is complete. Samples for the analysis of pigment composition in particulate profiles were also collected and the sample analysis is complete.

4. Analysis of pigment in samples collected on the CSS Dawson cruise.

Analysis of pigment in these samples is complete.

4. Additional Accomplishments:

1. Two manuscripts concerning (a) the transformation to phaeopigments and destruction of chlorophyll *a* during copepod grazing and (b) the chemical composition of copepod food and faecal pellets have been accepted for publication.

Manuscripts in press:

Head, E.J.H. Gut pigment accumulation and destruction by Arctic copepods *in vitro* and *in situ*. *Mar. Biol.* (in press)

Head, E.J.H. Comparison of the chemical composition of particulate material and faecal pellets at stations off the coast of Labrador and in the Gulf of St. Lawrence. *Mar. Biol.* (in press)

2. A manuscript has been prepared based on pigment analyses of samples from: water column profiles, copepod faecal pellets and sediment traps, from the 1990 JGOFS cruise. It has been submitted to the special 'JGOFS, North Atlantic Bloom Experiment' edition of *Deep-Sea Research*.

Manuscript submitted:

Head, E.J.H., Horne, E.P.W. Algal pigment transformation and vertical flux in an area of convergence in the North Atlantic. *Deep-Sea Res.* (submitted).

3. Experiments to investigate pigment destruction and transformation by copepods grazing on natural particulate matter, under a variety of *in vitro* conditions, were carried out on a cruise on the CSS Dawson during May 1991. Samples arising from this cruise have been analyzed.

#### 5. Goals/Expected Outputs for 1992:

1. Completion of sample analysis of material collected during the 1991 field season.
2. Preparation of a manuscript for publication, based on data obtained on the 1991 JGOFS and CSS Dawson cruises, concerning the transformation and breakdown of pigments by copepod grazing.
3. Participation in a JGOFS cruise to the sub-tropical North Atlantic and in investigations of the role of copepods in carbon and pigment flux.

#### 6. Background:

Highlights:

The results of pigment analyses of material from the 1990 JGOFS cruise have shown that chlorophyll a may be converted into phaeopigments either by autolysis or during grazing by copepods. The phaeopigments produced by the two processes are distinguishable by HPLC analysis and both accumulate in sediment traps. Including HPLC analysis in future studies of this type will help elucidate the pathways of pigment, and hence carbon, flux in the ocean.

Selected Involvements:

##### i. Collaborative Research -

Continued participation in International JGOFS, by memberships of committees for investigations of zooplankton physiological studies and pigment analysis (by HPLC).

##### ii. University Liaison -

##### iii. Communications -

Presentation of a paper at the ASLO meeting, held in Halifax, June 1991, entitled 'HPLC analysis of pigment in particulate material, copepod faecal pellets and sediment traps in the North West Atlantic'.

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Smith, R.E.H., Clement, P., Head, E.J.H. 1990. Night metabolism of recent photosynthate by sea ice algae in the high Arctic. *Mar. Biol.* 107: 255-261

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

##### iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

This is an essential part of the Division's overall study of structure and function of pelagic ecosystem.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 619

Section:

Project Title: Shore-Based Studies of Under-Ice Epontic and Pelagic Plankton Communities

Project Leader: Conover, R.

Other Researchers: Harris, L.

Work Activity: W.A.1.1.1.8

Key Words: Arctic research; zooplankton; secondary production; biological oceanography

1. Project Description:

The work is carried out on the ice during spring break-up, or from shore-based facilities, using helicopters or tracked vehicles to reach selected study sites. Ice camps are established and holes cut in the ice serve for deployment of sampling gear and the continuous monitoring of the physical environment. Some analyses are performed on the ice or at our permanent laboratory facility at Resolute Bay, NWT. The environment is harsh and much of the sampling equipment must be specially developed. Cooperation with physical scientists and engineers of the Polar Continental Shelf Project is vital.

2. Long-Term Objectives:

Describe in detail the sub-ice pelagic ecosystem and the life cycles of key species; describe the linkages between pelagic and epontic components; describe how organic matter fixed by epontic and pelagic communities enters into the food web supporting higher trophic levels in the north; and provide baseline information on the status of pelagic and epontic communities in winter with emphasis on the Canadian archipelago.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. An interactive field program in the Resolute area, with a largely American research team, headed by Dr. Glen Cota, University of Tennessee Knoxville during April and May, 1991 is being planned. At this time the DFO contribution is expected to be relatively small. A second trip is planned for July-August 1991. The principle investigator in each case will be Kent Gustavson, a Dalhousie graduate student, whose expenses and salary are largely covered by NSERC. Emphasis will be on the distribution and physiological ecology of *Pseudocalanus acuspes*, probably the most productive zooplanktonic organism in the Arctic Archipelago, and the subject of Mr. Gustavson's Ph.D. thesis research.

Kent Gustavson made two trips to Resolute, one from late April to late May and a second from late July to late August. His main interest has been in the distribution and feeding behaviour of *Pseudocalanus acuspes*, a northern boreal arctic opportunist. Part of the emphasis this spring has been to determine if selective feeding plays a role in success of the animal. Dr. Cota's group shared some of our facilities and were generally quite helpful to Kent. Gustavson has now switched to a M.Sc. program hoping to finish in early 1992.

2. A new project (No. 624), to be largely funded by DFO, is being submitted and, if funds become available, the scope of our research activities in the North will be considerably increased.

Funding in support of the new project (No. 624) was not forthcoming in 1991-1992 but we are hopeful that it can be initiated in 1992-1993.

4. Additional Accomplishments:

As coordinator for the Canadian Northwater Program, part of International Arctic Polynya Program (IAPP), I spent considerable time in preparation of a document originally intended for submission to NSERC as a Collaborative Research Initiative. Regrettably we are still unable to find sufficient funds in the Canadian community to cover basic logistical costs which NSERC is unwilling to furnish. As an alternative we believe that Northwater Research can only be pursued on an opportunistic basis for the present. In this regard a spring trip was arranged on the MV Arctic, owned by Canarctic Shipping Company Ltd., from Sydney, N.S. to Arctic Bay, N.W.T. with a diversion into the Northwater. The MV Arctic is a large, ice-breaking bulk carrier but reasonably maneuverable and very stable. The cruise, May 7-19, 1991 to Northwater Polynya showed evidence for upward heat transport and intense biological activity in eastern Baffin Bay (near Greenland). Integrated chlorophyll concentrations in excess of 300  $\mu\text{g M}^{-2}$  were common. Despite the large biomass of pigment, nitrate concentrations were still in excess of 5  $\text{mmol m}^{-3}$  over virtually all the Northwater. The Atlantic copepod *Calanus finmarchicus* was common in the warmer, richer water off Greenland while, to the west, pigment levels were lower and a polar congener, *C. glacialis*, was abundant. The larger arctic species, *C. hyperboreus*, which normally breeds under the fast ice in Barrow Strait in late winter and early spring, had completed spawning, was feeding vigorously and showed evidence for lipid storage.

Comparison with events near Resolute, NWT, suggests that the seasons are advanced by 6-12 weeks in Northwater. The results are being prepared for publication.

#### 5. Goals/Expected Outputs for 1992:

Another MV Arctic cruise is planned for the spring of 1992. On this occasion we hope to have a deep water winch to study the vertical distribution of the zooplankton and to make the first ever primary production measurements, along with nutrient, chlorophyll and particulate carbon determinations in Northwater Polynya.

We also hope to initiate the overwintering program mentioned earlier in this document, but details will be covered under Project No. 624.

As an invited participant, I will attend a symposium and workshop sponsored by the Churchill Northern Studies Centre on "Circumpolar Ecosystems in Winter", February 12-16, 1992. My paper "Survival Strategies in Polar Zooplankton" will be published, as part of the proceedings, in ARCTIC AND ALPINE RESEARCH.

#### 6. Background:

##### Highlights:

The MV Arctic cruise has already been mentioned.

##### Selected Involvements:

##### i. Collaborative Research -

The MV Arctic cruise was a collaborative project involving scientists from IOS, BIO and Laval University. The present plan is to summarize our observations, which must still be considered as preliminary, in a multi-authored paper, perhaps for submission to an express journal.

##### ii. University Liaison -

My role as a student advisor at Dalhousie has been mentioned under Project No. 609. I gave a talk to the Friday seminar series in the Department of Biology in November on the biology of arctic zooplankton.

##### iii. Communications -

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Conover, R.J. and M. Huntley. 1991. Copepods in ice-covered seas - distribution, adaptations to seasonally limited food, metabolism, growth patterns and life cycle strategies in polar seas. *J. Mar. Syst.* 2:1-41.

##### ii. Interpretive Scientific -

Conover, R.J., L.R. Harris and A.W. Bedo. 1991. Copepods in cold oligotrophic waters - how do they cope? Proceedings of the Fourth International Conference on Copepoda; *Bull. Plankton Soc. Japan*, Spec. Vol. 177-199 pp.

##### iii. Scientific and Technical -

##### iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

This work represents a major portion of the current Divisional work in the Arctic.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 620

Project Title: Summertime Shipboard Studies in the Eastern Canadian Arctic

Project Leader: Head, E.

Other Researchers: Harris, L.

Work Activity: W.A.1.1.1.8

Key Words: Arctic research; zooplankton; secondary production; biological oceanography

1. Project Description:

Arctic zooplankton are studied during the open water period (July-September) when pelagic primary production and algal biomass are at their peak. During this period copepods congregate in the surface waters where they apparently ingest enough food and store enough fat to allow them to survive the 9-month Arctic winter. Aspects of the ecology and biology of Arctic zooplankton are investigated, including vertical distribution, biochemical composition, feeding behaviour, ingestion rate, assimilation efficiency and metabolic rates.

2. Long-Term Objectives:

To characterize the biochemistry and physiology of Arctic pelagic copepods during their active feeding season and investigate adaptive aspects of copepod behaviour, physiology and biochemistry in the Arctic environment. To assess the role of copepods in utilization of primary production and their contribution to carbon vertical flux through fecal pellets during the open water season.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

This project is expected to remain dormant again in 1992, but see below under "Collaborative Research".

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:6. Background:

Highlights:

Selected Involvements:

## i. Collaborative Research -

At the invitation of Dr. E. Carmack (Institute of Ocean Sciences, Sidney) a research program has been submitted for sampling and experimental work to be carried out on a joint Canadian/U.S. ice-breaker cruise, which has been proposed for the summer of 1993.

## ii. University Liaison -

## iii. Communications -

## iv. Contracts Administered -

## v. Other -

7. Publications:

## i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

Project temporarily dormant.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 621

Section:

Project Title: Dynamics of Microbial Metabolism and Particle Flux

Project Leader: Kepkay, P.

Other Researchers: Foda, A.

Work Activity: W.A.1.1.1.8

Key Words: bacteria; particle-aggregate studies; microbiology; biological oceanography

1. Project Description:

This project utilizes the methods of microbiology and fluid mechanics to determine the role of particle aggregation in the regulation of microbial activity and particle flux. Microbial respiration and nutrient regeneration are stimulated by the coagulation of colloid-sized DOC (dissolved organic carbon) on bubble surfaces in the upper ocean. This process of surface coagulation is, in effect, a physical forcing of nutrient regeneration, and regulates the flux of carbon between DOC (one of three globally-important reservoir of organic carbon) and CO<sub>2</sub>. It also regulates the flux of CO<sub>2</sub> between new and regenerated primary production. Given the possibility that primary production can sequester excess atmospheric CO<sub>2</sub> in the ocean, and given the close association of surface coagulation with DOC, gas flux and primary production, this project is a key element of JGOFS or any other program concerned with CO<sub>2</sub> and the greenhouse effect.

2. Long-Term Objectives:

Determine: (a) the role of coupled physical and microbial systems in the formation, maintenance and breakdown of particle aggregates; and (b) the effect of these organic-bacterial aggregates on the biogeochemical cycling of DOC and the regeneration of nutrients in the open ocean. The work is relevant to JGOFS, and is core microbiological and oceanographic research in the Biological Oceanography Division.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue the development of computerized oxygen electrode techniques. (Kepkay)

A pulsed oxygen electrode system has been developed to determine rates of photosynthesis at different light intensities. A paper is in preparation on results obtained with laboratory cultures. From these results, it is clear that the light history of phytoplankton cells is critical in determining both the onset and an increase of net photosynthesis as light intensity is increased. The onset of net photosynthesis at low light levels may also be critical in determining the rate of DOC release by actively growing cells.

2. Continue to investigate effects of turbulence on particles and particle aggregates as microbial environments. (Kepkay)

Surface coagulation is a primary mechanism of coagulation in the upper ocean, as bubbles entrained by breaking waves remove colloid-sized DOC from the water column. Microbial respiration is stimulated by this physical scavenging of organic carbon from solution and has three important consequences: (i) DOC in the ocean may be far more reactive than previously thought. This solves a long-standing paradox, where DOC in seawater appears to be remarkably unreactive, yet has to be reactive to maintain a global balance between organic carbon in the ocean and CO<sub>2</sub> in the atmosphere. The respiration induced by surface coagulation may well be the process required to maintain this balance; (ii) Primary production (the main mechanism of sequestering excess atmospheric CO<sub>2</sub> in the ocean) is affected by surface coagulation because microbial nutrient regeneration is stimulated along with respiration. This change in the pattern of nutrient regeneration alters the balance between new regenerated production; (iii) The short-term flux of CO<sub>2</sub> between atmosphere and ocean is directly affected, with the respiration induced by surface coagulation either equal to or greater than measurements of the short-term flux of CO<sub>2</sub> and the rate of CO<sub>2</sub> consumption by primary production.

Data from JGOFS spring bloom cruises show that the induction of microbial respiration by surface coagulation is closely coupled to both sea state (defined in terms of swell height and wind speed) and primary production. A paper on the data has been published. The role played by DOC in regulating the coupled physical and biological systems defined in the data sets remains to be determined, but a paper on the relationship between DOC and primary production at the sediment-water interface has been published. In addition, a new-generation instrument for the analysis of DOC by high temperature catalytic oxidation (HTCO) has recently been purchased and taken to sea (on CSS Hudson cruise 91-001). The results are summarized in a paper accepted for publication and show, for the first time, that DOC in surface waters can be simply correlated with such standard oceanographic parameters as chlorophyll concentration and apparent oxygen utilization (AOU). This obvious, but unique, finding highlights the central position of DOC in carbon cycling in the upper ocean.

A keynote paper has been published which provides a theoretical framework for interpreting the fluid dynamics of organic particle coagulation and the biological responses induced by this coagulation. Models of the mass transfer of organic particles in fluid shear show that organic colloids, as particles of about 1 mm in diameter, are a source of nutrients which remains largely inaccessible to bacteria in surface waters. Bubbling, and surface coagulation of these colloids (along with other forms of coagulation), greatly enhances the mass transfer of this untapped reservoir of nutrients to the bacteria.

This work is important because it is the theoretical foundation for any future studies of coagulation and the biological lability of DOC in the ocean. The work is also important in light of the results obtained at recent NATO workshop on sub-micron particles and the relationship of these small, colloid-sized particles to elevated DOC concentrations in the upper ocean. A paper has been published on the results from the sub-micron particle workshop.

3. Further define the potential nutritional and enzymatic status of organic aggregate bacteria. (Foda)

The bacteria associated with organic aggregates in the water column adapt to and control the nutrients regenerated to primary production. Given that surface coagulation increases both the magnitude and rate of this regeneration, the detailed physiological characterization of bacteria involved in the process provides information which is crucial for any quantitative analysis of the amount and type of nutrients regenerated.

One paper has been submitted and one is in preparation that characterize the suite of bacteria isolated from organic aggregates produced by surface coagulation.

#### 4. Additional Accomplishments:

#### 5. Goals/Expected Outputs for 1992:

1. Continue the development of computerized oxygen electrode techniques. (Kepkay)
2. Continue to investigate effects of photosynthesis, DOC and turbulence on particle aggregates as centers of microbial activity. (Kepkay)
3. Further define the potential nutritional and enzymatic status of organic aggregate bacteria. (Foda)

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

B.D. Johnson (Dalhousie), organic aggregates produced by surface coagulation.  
P. Schwinghamer (DFO, Newfoundland), DOC and primary production at the sediment-water interface.

##### ii. University Liaison -

See above.

##### iii. Communications -

A considerable amount of time has been spent preparing talks for local schools and in supervising a junior high school science project. This work is part of an ongoing effort to communicate science to the general public (also reflected in contributions to BIO Open House '90 and numerous interviews with the press in 1989).

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Kepkay, P.E. 1991. Surface coagulation and microbial respiration in response to local advection and sea state in the North Atlantic. *Mar. Ecol. Prog. Ser.* 69: 143-147.

Schwinghamer, P., P.E. Kepkay and A. Foda. 1991. Oxygen flux and community biomass structure associated with benthic photosynthesis and detritus decomposition. *J. Exp. Mar. Biol. Ecol.* 147: 9-35.

Johnson, B.D. and P.E. Kepkay. 1991. Colloid transport and bacterial utilization of oceanic DOC *Deep-Sea Res.* in press.

Longhurst, A.R., I. Koike, W.K.W. Li, J. Rodriguez, P. Kepkay, F. Partensky, B. Bautista, J. Ruiz, M. Wells and D.F. Bird. 1991. Submicron particles in northwest Atlantic shelf water. *Deep-Sea Res.* in press.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to be productive of excellent publications. It is an important part of the Division's work towards understanding the structure and function of the ocean ecosystem.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 622

Section:

Project Title: Mathematical Models of Marine Pelagic Communities

Project Leader: White, G.

Other Researchers: Platt, T.

Work Activity: W.A.1.1.1.8

Key Words: modelling; biological oceanography

1. Project Description:

Quantitative models play a vital role in the interpretation of field data. Models provide timely and cost effective answers for questions which would otherwise require expensive field studies. In cases requiring new field studies, modelling helps to ensure that resources are deployed to maximum benefit. Mathematical methods are necessary tools in the development of quantitative models. The effectiveness of mathematical methods stems, however, from the power of abstraction in facilitating interchange between diverse subject areas. This project includes research to: a) extend existing models and develop new types of models; b) analyze mathematical properties and develop analytical or numerical solution procedures for models of marine ecological systems; c) use models to better understand ecological processes; d) explore relationships between models for marine pelagic communities and those for other ecological systems; and e) expand mathematical knowledge in areas applicable to ecological modelling.

2. Long-Term Objectives:

Enlarge the range of space- and aspect-structured dynamic models for pelagic communities. Enhance the practical utility of models by improving analytical and numerical solution procedures. Develop relationships between distribution patterns (in size and space) and seasonal life cycles, physiological condition, and productivity in model systems. Contrast relationships developed from modelling studies with those observed in natural systems. Use models to develop new relationships between key ecological variables and properties observable in the field. Apply the results to extend and consolidate scientific understanding of marine pelagic communities in a way that will provide insight into the roles of pelagic biota in the global CO<sub>2</sub> cycle and the production of commercial species.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete the manuscript on measurement of aliasing effects and extend the work to include Chebyshev methods. Paper.

Computations to measure aliasing effects have not been completed due to problems with the BIO Cyber. Chebyshev methods were implemented and applied to a practical problem, but a rigorous examination of the method has been delayed by other priorities.

2. Begin systematic evaluation of existing numerical techniques to determine their suitability for biological modelling. Paper.

Many existing methods have proven to be unsuitable. Several classical techniques are being updated for use with symbolic calculation procedures.

3. Improve the environment for numerical computation. Efforts will focus on increasing the accessibility of high quality software, upgrading of computing systems and software to current standards, improving communication of information about bugs and limitations of existing systems to scientists, and assistance with solving performance problems.

Major additions to the Division's computing resources, a larger than usual number of cruises, strikes, frequent network outages, and a large number of equipment failures meant that this task required a greater than expected effort.

The most involved task was the installation and configuration of a 24-bit image processing system based on a Stardent Unix super-mini computer. Dr. White provided continuity and expertise on Unix and C. He ported several key applications, including bash, TeX, gawk, bison, gnu make, gnuplot, and an archive client to the Stardent and prepared a guide to assist users unfamiliar with the Unix environment in porting applications to the Stardent.

4. Additional Accomplishments:

Dr. White was involved in configuration of two Macintosh systems, one used to control an optical disk player, the other to control a film printer and Kodak color printer for the production of images, and often assisted users and helped maintain these systems.

In 1991 the Division experienced an unusually large number of disk failures, many at times when spares, documentation, and key personnel were at sea. Dr. White helped resolve three complete failures of PC/AT systems (one requiring the use of a data recovery service), two failures of high capacity SCSI drives, recurring "loss of data" episodes involving several 80386 systems, and one complete loss of data on a Macintosh system.

Dr. White participated in the design and installation of the Division's ethernet network and is called on to help resolve problems on a daily basis. He first identified incompatibilities between the BIONet VAX and several common MS-DOS packages that were disrupting communications throughout the region.

Dr. White has temporarily assumed many of the system management responsibilities for the Division's two NeXT systems. This is the most complete TeX implementation at BIO. A NeXT was used to satisfy demanding requirements for a camera-ready document being prepared by S. Smith of MFD using TeX.

Dr. White is often consulted on problems in numerical computing, Unix, and networking by scientists outside the Division.

5. Goals/Expected Outputs for 1992:

1. It is clear that efforts need to be focused on improving the reliability of the Divisions's basic computing facilities so that more effort can be devoted to research.
2. Investigate the use of sums of exponentials for approximation of terms describing the decay of light intensity with depth.
3. Improve the environment for numerical computation.

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -
- ii. University Liaison -
- iii. Communications -
- iv. Contracts Administered -
- v. Other -

Dr. White played an active role in the creation of UniForum Atlantic, a regional user's group for Unix and Open Systems users.

Dr. White organized the access to electronic mail facilities for ASLO participants and prepared a guide for the use of participants.

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project is now metamorphosing from a research initiative into a computing and mathematical support function.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Biological Oceanography

Project No.: 624

Section:

Project Title: Year Round Plankton Research in the Arctic

Project Leader: Conover, R.

Other Researchers: Harris, L.

Work Activity: W.A.1.1.1.8

Key Words: Arctic research; zooplankton; primary production; secondary production;  
winter research; ice algae1. Project Description:

The original proposal was not funded for 1991. In slightly modified form we hope to get it started in 1992. The project is intended to fill in important gaps in our seasonal coverage, including the "dark" season, of pelagic and ice-related biological research in the arctic and is an integral part of the Green Plan submission titled: "Climate change and production in the high arctic". Present plans call for initiating preparations, such as installing current meters, sediment traps, and repairing gear and general maintenance in mid-August. Field observations will be initiated near the end of August 1992 with nearly continuous monitoring through into November. We hope to have at least one person at Resolute throughout this period. During "total" darkness (mid-November to mid-February), we plan at least two trips of shorter duration. Another period of intensive study will begin in late March 1993 and will be continued more or less continuously through the end of August 1993. Over the entire year, particulates, nutrients, chlorophyll, vertical distribution of zooplankton, proximate biochemistry of zooplankton (frozen samples) and sedimentation will be sampled routinely whether or not BIO personnel are present. Physiological measurements (respiration, excretion, feeding, determination of reproductive state) will be determined on a regular basis on field populations when BIO personnel are present. We intend to establish captive populations of zooplankton dominants in the wet laboratory which will be maintained on natural food resources and their physiology will be monitored for comparison with natural populations on a regular basis. Several periods in the annual seasonal cycle, particularly around freeze-up and again during the melt and break-up, will receive particularly intensive monitoring. Primary production, benthic biology, observations on certain mammals and contaminants monitoring will also be carried out on a regular basis by collaborating colleagues over the entire year. Sampling will be carried out from the ice during late fall, winter and spring and from inboard launches during open water season.

2. Long-Term Objectives:

Our objectives are still to describe in detail the sub-ice pelagic ecosystem in the Canadian Arctic and the life cycles of key species; to describe the linkages between pelagic and sympagic components; to describe how organic matter fixed by sub-ice and pelagic plant communities enters into the food web thereby supporting higher trophic levels; and to provide baseline information on the status of pelagic and sympagic communities at all seasons for comparison with the same or similar ecosystems in response to future climatic conditions.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. To examine the distribution and population structure of *Pseudocalanus acuspes*, and other important copepod species, at freeze up.
2. To verify the existence of ontogenetic migrations, their season of occurrence and importance in the same species, and other common copepods in the region.
3. To verify the existence and to determine the magnitude of a fall bloom of primary producers either in the water column or on the under ice surface, or both.

As this project was not funded in 1991, no significant accomplishments can be reported.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. To examine the vertical distribution and population structure of all the dominant zooplankton species, but particularly that of *Pseudocalanus acuspes*, through the late summer through freeze-up. An important question is whether all common species undergo a reduction in metabolism in the non-productive season and whether a true "diapause" is practiced by any of them.
2. To verify the existence and timing of ontogenetic migrations, particularly in *Pseudocalanus*, which is usually closely associated with the ice at the time of the spring bloom of ice-algae.

3. To verify the existence and the magnitude of a fall bloom of primary producers either in the water column or on the under-ice surface or both.

6. Background:

Highlights:

I attended a meeting at the F&O laboratory in Winnipeg in late November to plan logistics and a scientific program for the over-winter experiment beginning in the fall of 1992. It was attended by a dozen or more scientists from BIO, IOS, several universities and the Winnipeg lab.

Selected Involvements:

i. Collaborative Research -

The program will be a joint venture between DFO central, who own the facilities at Resolute, and two groups from BIO, Biological Oceanography, which will concentrate on interactions between climate and productivity, and Habitat Ecology, which will run a program on contaminants in the food web emphasizing pathways of entry. In addition we will supply the logistical base for several scientists from other Canadian groups during the dark period.

ii. University Liaison -

I hope to have a German exchange fellow Dr. Nicolai Mumm, from the Institute for Polar Ecology, Kiel University, Germany participating in the program for most or all of the over-winter period. He will be supported on a NATO fellowship.

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project may be able to be reanimated during 1992/93.

**HABITAT ECOLOGY DIVISION**

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 000

Section:

Project Title: Division Administration and Management

Project Leader: Gordon, D.C.

Other Researchers: Keizer, P.D.; Morgan, S.P.; Parnell, J.E.; Rowell, T.W.; Vass, W.P.

Work Activity: W.A. 1.1.3.1

Key Words: administration; financial management; personnel management; scientific management

1. Project Description:

Administration and financial, personnel, and scientific management of the Habitat Ecology Division.

2. Long-Term Objectives:

Administer the Habitat Ecology Division efficiently, provide scientific leadership and coordination in interpreting and accomplishing the mandate of the Division, and procure financial resources for carrying out Divisional programs.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Administer and manage the Habitat Ecology Division efficiently. (Gordon, Keizer, Morgan, Parnell, Rowell, Vass)

Administrative procedures have proceeded smoothly during 1990 despite a continuing heavy workload and personnel changes. In June 1991, term employee T.M. Stanislaw departed the Division and S.P. Morgan returned from a one-year period of leave without pay.

2. Provide scientific leadership and coordination in interpreting and accomplishing the mandate of the Habitat Ecology Division. (Gordon)

The Divisional program continues to evolve in response to the priorities established by the scientific community, DFO, and departmental clients. The PERD-funded program on potential Georges Bank drilling impacts has continued under the guidance of a multi-agency steering committee. The aquaculture impacts project has continued, and plans are underway for a modelling workshop with managers and industry. The AFAP-funded gillnet and trawling impact project is now well established. Plans have been made for a new habitat sensitivity mapping project using a Geographic Information System (GIS).

3. Seek external funding for new programs that cannot be supported with A-Base resources. (Gordon)

External funding was again obtained from PERD to continue studies of the potential impact of hydrocarbon exploration on Georges Bank scallop populations. AFAP funding for the gillnet and trawling impact project has continued. New Green Plan funds have been obtained for projects dealing with Arctic contaminants and habitat sensitivity mapping. Proposals for AFAP aquaculture funds were submitted but not funded.

4. Liaise with other Science Sector Divisions, the Marine Assessment and Liaison Division, and the Habitat Management Branch to implement the DFO Fish Habitat Management Policy. (Gordon)

Coordinated the Regional phycotoxin program and PERD 6.7 impact program. Sat on numerous habitat-related committees and attended many meetings. Helped build improved collaboration with other Divisions and Departments.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Administer and manage the Habitat Ecology Division efficiently. (Gordon, Keizer, Morgan, Parnell, Rowell, Vass)
2. Provide scientific leadership and coordination in interpreting and accomplishing the mandate of the Habitat Ecology Division. (Gordon)
3. Seek external funding for new programs that cannot be supported with A-Base resources. (Gordon)
4. Liaise with other Science Sector Divisions, the Marine Assessment and Liaison Division, and the Habitat Management Branch to implement the DFO Fish Habitat Management Policy. (Gordon)

5. Review new purchasing procedures and provide staff with clear instructions for following them.  
(Morgan)

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

The Divisional Office is well-organized and runs efficiently. Deadlines are met and staff are satisfied with services provided. A considerable amount of time is devoted to attempting to procure new funding to keep existing projects running and to start new ones.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 700

Section:

Project Title: Fish Habitat Assessment Advice

Project Leader: Gordon, D.C.

Other Researchers: Staff, Habitat Ecology Division

Work Activity: W.A.1.1.3.1

Key Words: habitat; advice

1. Project Description:

Provide timely and up-to-date scientific advice on freshwater, estuarine and marine habitat issues as requested by DFO clients, in particular the Fisheries and Habitat Management Branch.

2. Long-Term Objectives:

Contribute to Science Sector support of the DFO Fish Habitat Management Policy which calls for maintenance of current habitat productive capacity, restoration of damaged habitats, and habitat development. Ensure that the best possible scientific information and opinions are available when important decisions are made which affect the future health of the natural environment. Advice is also given to private industry and international organizations.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Serve on habitat-oriented committees and provide scientific habitat advice as requested.  
(Staff, Habitat Ecology Division)

Served on 13 regional, two zonal, seven national, and 12 international habitat-related committees; reviewed 15 habitat documents for Science, Fisheries and Habitat Management Branch, National Research Council, and the National Oceanic and Atmospheric Agency; prepared four habitat reports for DFO and the Gulf of Maine Council on the Marine Environment; responded to over 50 information requests from DFO, and other government departments and industry; provided field assistance on 11 occasions to evaluate habitat conditions; attended over 40 meetings or workshops dealing with habitat issues; and presented over 32 lectures or interviews to DFO staff, other government departments, international meetings, universities, various media types, schools, industry, and the public at large.

Major habitat issues addressed included: Long-Range Transport of Airborne Pollutants (B.T. Hargrave); Georges Bank hydrocarbon exploration/development (P.C. Cranford, D.C. Gordon); Annapolis Basin clam mortality (T.W. Rowell); Halifax Harbour (B.T. Hargrave, D.C. Gordon); shellfish toxins (S.R. Durvasula, J. E. Stewart, P.D. Keizer, D.C. Gordon); effects of ghost fishing gillnets (G.C. Harding, W.P. Vass); effects of mobile fishing gear on benthic habitat (S.N. Messieh, D.L. Peer, T.W. Rowell, W.P. Vass, D.C. Gordon); the environmental impacts of aquaculture (J.E. Stewart, P.D. Keizer, W.L. Silvert, B.T. Hargrave, D.C. Gordon); harbour porpoise bycatch in the Bay of Fundy (P.F. Brodie); ballast water impacts (S.J. Kerr and S.R. Durvasula); and habitat sensitivity mapping (P.R. Boudreau and S.N. Messieh).

Major efforts of particular note include preparing a prototype habitat profile on lobster for habitat managers (G.C. Harding) and advising operations and the fishing industry on harbour porpoise population dynamics (P.F. Brodie).

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Serve on habitat-oriented committees and provide scientific advice as requested. (Staff, Habitat Ecology Division)

6. Background:

Highlights:

Selected Involvements:

- i. Collaborative Research -

This project is heavily dependent upon collaboration with numerous scientists in other Divisions; H.B. Nicholls and staff in the Marine Assessment and Liaison Division; and A. Ducharme and staff in the Habitat Management Branch.

ii. University Liaison -

iii. Communications -

Numerous habitat-related talks and interviews were given as documented above.

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to provide expert and timely advice on a large number of habitat issues. It responds to all requests received, both internal to DFO and from outside clients. It helps bridge a gap between scientific research and environmental management.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 701

Section:

Project Title: Microbial Ecology

Project Leader: Stewart, J.E.

Other Researchers: Marks, L.J.

Work Activity: W.A.1.1.3.2

Key Words: habitat research; microbiology; bacteria; aquaculture

1. Project Description:

Development of more rapid techniques for determination of bacterial types (genera), abundance, and activities; application of those techniques in areas of interest to gauge impact of man-derived loadings on habitats, i.e. fish farms, shellfish culture units, and areas flooded by sewage compared with control area; measurements of impacts of surplus antibiotics and their effects on microbial systems; ultimately develop improved methods to measure nutrient flow via microorganisms and protozoa, and evaluate control over microbial activities by predators such as the Bdellovibrio and relevant protozoa.

2. Long-Term Objectives:

Assess and evaluate the roles and activities of microorganisms and their immediate predators (protozoa) in the marine and freshwater environments as agents of mineralization and converters and conveyors of nutrients and the influence of specific factors on this system. Since up to 50% of the primary production is channelled through the microbial system with possibly up to one-half of that entering the food chain through predation of bacteria, this is an important route in gauging overall aquatic production. Coupled with this is the fact that the microbial system is the route whereby organic waste such as sewage, surplus fish food and faeces, and dead material (plant and animal) is recycled and returned to the metabolic pool in useable forms. Obviously these systems can be affected by increased loadings and by specific contaminants including the large quantities of antibiotics from aquaculture. These have the capacity to materially alter microflora and induce bacterial resistance to antibiotics posing among other aspects the threat of producing dangerous strains of pathogens against which fish farmers will have little defense. These studies should aid in answering questions on productivity and habitat questions such as those concerned with the impact of aquaculture on coastal environments.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

Not as much progress has been made on this project as anticipated, partly because the money that was available did not permit as much work as we had planned. In addition, it was decided to use the bulk of the money assigned to acquire a Microplate Reader and supplies to provide the foundation for these studies in which serological methods and gene probes will be integral parts. The Microplate Reader (ELISA) and dispenser/washer (to be obtained next year) are essential tools in this project and in the Toxin Project 702.

1. Studies on serological methods to determine microbial biomass. Through collaboration with staff at the Atlantic Veterinary College and others we will concentrate on acquiring antisera to unique bacterial components and use these for method development.

Arrangements have been made with other DFO staff to use antisera specific for *Aeromonas salmonicida* and to prepare probes for determining this organism's longevity in sediments around fish farms and its drug resistance. Other index organisms will be added to flesh out the work.

2. Studies comparable to Goal 1 above but using natural agents for the identifications of bacteria and measurement of the microbial biomass. We anticipate capitalizing on such items as the lectin from scallops described by Dr. R. Brown (Dalhousie University). This agent is specific for a bacterial component and should aid in determining and confirming bacterial identities and biomass.

A lectin preparation, conjugated with fluorescein, prepared by Dr. R. Brown (Dalhousie University), was given to us by Ligatech with strict conditions. When the conditions of use are considered and the capacity of the system as demonstrated are considered, it may be wiser to await the appearance of this product as an article of commerce before going further with it.

3. Initiation of studies to determine occurrence of antibiotic resistance among bacteria associated with salmon farm sediments, i.e. in areas of high antibiotic use and contrast these with areas where antibiotics are not in use. Preliminary results are anticipated which should lay the foundation for quantitative comprehensive surveys.

Because of spending the money on the Microplate (ELISA) Reader, the progress was limited to that under Goal 1.

4. If time permits, the methods developed above will be applied in field situations to gauge or assess the impact that the organic wastes and surplus antibiotics have upon microbial populations, the mineralization rates and induction of drug resistance in key organisms including fish pathogens. Most of the work on this aspect will be preliminary and exploratory in 1991.

See general opening statement and Goal 1.

5. Follow up contacts with Norwegian colleague's arrangements for collaboration in the research areas listed in Goals 3 and 4.

Discussions have been undertaken with Dr. A. Ervik (Bergen, Norway), but firm arrangements will be made only after progress under Goals 3 and 4.

6. Complete arrangements with Norwegian colleagues to hold and participate in the workshop to be held in Bergen in August 1991.

Arrangements were made and a full agenda developed for August of 1991. Unfortunately, the funding for participation by the Canadian contingent was not available and, as a consequence, the workshop was cancelled for 1991.

#### 4. Additional Accomplishments:

#### 5. Goals/Expected Outputs for 1992:

1. Continue and extend the development of quantitative methods to measure microbial biomass and associated activities.
2. To begin, under trial conditions, to apply these methods to determine the impact that organic substances, such as surplus fish foods, faeces from cultured species, sewage, and antibiotics have on microbial activities, including mineralization.
3. Attempt to develop a better understanding of the control exercised over the microorganisms by predators (viruses, other bacteria, etc.) by utilizing Goals 1 and 2.
4. If feasible, attempt, for a second time, to arrange the Canada/Norway Workshop on Environmental Impacts of Aquaculture.

#### 6. Background:

Highlights:

Acquisition of Microplate Reader.

Selected Involvements:

##### i. Collaborative Research -

V. Zitko - Department of Fisheries and Oceans, Marine Chemistry Division, St. Andrews, N.B.

C. Levings - Department of Fisheries and Oceans, Pacific Region, West Vancouver, B.C.

##### ii. University Liaison -

R. Brown - Dalhousie University, Halifax, N.S.

F. Markham - Atlantic Veterinary College, Charlottetown, P.E.I.

##### iii. Communications -

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project is still acquiring the necessary equipment. Progress has been hampered by inadequate common-use autoclave facilities at BIO. Hopefully, all equipment will be in place by 1992, so substantive progress can be made. Effort is being made to obtain additional funding under the AFAP aquaculture program. A project was recommended by DFO Headquarters for funding in fall 1991, but then the Minister changed the rules.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 702

Section:

Project Title: Microbial-Marine Toxin Interactions

Project Leader: Stewart, J.E.

Other Researchers: Durvasula, S.R.; Marks, L.J.

Work Activity: W.A.1.1.3.2

Key Words: domoic acid; aquaculture; habitat research; microbial degradation; paralytic shellfish poisons (PSP)

1. Project Description:

Preparation of a literature review of the work on the marine toxins known as paralytic shellfish poisons (PSP), domoic acid, diarrhetic shellfish poisons (DSP), and brevitoxin; studies leading to explanations for the production of large amounts of domoic acid (growth and biosynthesis); studies on microbial degradation will be carried out to determine which organisms degrade domoic acid and by which biochemical routes. Studies of the microbial involvement in domoic acid and PSP production.

2. Long-Term Objectives:

Provide an understanding of previous work on marine toxins of relevance to the Atlantic Zone and aid in providing an understanding of the processes whereby marine toxins are produced and their ultimate disposition in nature.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Further attempts will be made to produce an axenic culture of the diatom N. pungens.

One axenic culture has been produced of a non-domoic acid-producing strain, and two more domoic acid producers are in the works; and it is anticipated that they will be bacteria-free by January 1992.

2. With the acquisition of the axenic diatom, culture determinations will be made on its capacity to produce domoic acid axenically and the factors affecting this.

Dependent on success in Goal 1.

3. With the axenic and non-axenic cultures of Alexandrium tamarense and A. fundyense, studies will be undertaken to determine the role or influence of microorganisms in the production of the saxitoxin family of toxins.

A tissue culture bioassay was standardized and evaluated, and the endpoint determination automated and applied to PSP extracts in parallel with mouse bioassay up to moderately high concentrations of PSP. The two assays gave identical results. The tissue culture bioassay permitted extensive trials with both cultures in which it has been shown that microorganisms play a significant role in the biosynthesis of PSP toxins. (Jellett)

4. The capacity of the bacteria shown to produce domoic acid independently of the diatom will be examined in depth, and the nature of the interaction with N. pungens will be investigated in detail.

A problem of identification has arisen. One group of chemists identify the material as domoic acid, but another disputes this. With the aid of the ELISA method and different extraction procedures, this difficulty will be tackled to resolve the compound's identity. The problem seems to be related to metabolic precursors and synthesis of interfering amino acids.

5. With the current supplies of domoic acid and the acquisition of more, the fate of domoic acid in the environment will be explored. Experiments to determine whether it is degraded by microorganisms and to what will be mounted and an investigation of the frequency of this capacity and its distribution will be determined.

Two grams of domoic acid were purchased, and the impact on bacteria isolated from Bedford Basin (Foda) and Cardigan River muds (Pfeiffer and Stewart) was examined. Virtually all bacteria were inhibited in their respiration and growth by both domoic and kainic acids in a wide range of concentrations. A few bacteria could tolerate the domoic acid and, with the presence of yeast extract and other substrates, showed what was probably a co-oxidation of domoic acid.

4. Additional Accomplishments:

1. Improvement and automation of the tissue bioassay method (see 3.3 above).

Scientists at both the St. Andrews Biological Station and Inspection Services Branch have expressed interest in the tissue culture assay method and wish, in the both cases, to collaborate, and in the case of Inspection Services Branch, to learn the method and incorporate it into their program as an alternate to the live animal assays.

2. Virtual completion of phycotoxin review manuscript.

5. Goals/Expected Outputs for 1992:

1. Advance the studies on the fate (biodegradability) of domoic acid in light of results obtained in 1991.
2. Expand studies on the role of microorganisms on the production of marine toxins by phytoplankton to capitalize on the results obtained in 1991.
3. Arrange for publication of phycotoxin review.

6. Background:

Highlights:

Tissue culture bioassay development.

Selected Involvements:

i. Collaborative Research -

Joanne Jellett (Post-doctorate Fellow) is working in this laboratory on microbial involvement in the production of PSP in the course of which the tissue culture bioassay system was improved and automated. Collaboration with Inspection Services Branch showed that this method was more sensitive than the mouse bioassay and was a distinct possibility as an alternative to live animal assays.

Collaboration with National Research Council, Ottawa, occurred with domoic acid studies, A. Lawrence, on compounds produced by bacteria and H. Truelove, National Health and Welfare, Ottawa, on ELISA determination of domoic acid

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

- i. Primary -
- ii. Interpretive Scientific -
- iii. Scientific and Technical -
- iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project is now hitting full stride after a period of assembling a laboratory and equipment. The support of a full-time Post-doctoral Fellow (Joanne Jellett) has been a great benefit since the only other support is a half-time biologist and the project leader is involved in numerous other activities on behalf of DFO. The project should produce some scientific publications in 1992. It is especially important to arrange for the publication of the phycotoxin review prepared over the last three years.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 703

Section:

Project Title: Physiological Ecology of Toxic Algae

Project Leader: Durvasula, S.R.

Other Researchers: Stewart, J.E.; Yeats, P.

Work Activity: W.A.1.1.3.2

Key Words: DSP, domoic acid; aquaculture; habitat research; physiology; perturbations; microcosms; nutrient stress

1. Project Description:

Data from the phytoplankton monitoring program showed the occurrence of *Nitzschia pungens* f. *multiseriis* and *N. pseudodelicatissima* at all five coastal stations off Nova Scotia. These two diatoms are known to produce under certain culture conditions the neurotoxin, domoic acid. Although natural blooms of these two diatoms did not occur so far in our waters, the potential for development of blooms of these diatoms should not be ruled out. As has been known, all blooms may not be necessarily toxic and a physiological stress seems to be a factor in the production of phycotoxins (Subba Rao et al. 1990; 1991).

Analyses of phytoplankton monitoring program data collected since 1988 at five stations in the coastal waters of Nova Scotia showed the presence of toxigenic strains of *Nitzschia pungens* f. *multiseriis*. Its seasonal distribution followed the temperature cycle, exhibiting a preference for 15°C at Woods Harbour and Digby, N.S. The maximum abundance was <0.25 million cells per litre. Since a potential for the development of harmful toxic *Nitzschia* blooms exists at these sites, perturbation experiments would be carried out to establish the environmental variables that would induce such blooms.

A study is proposed along the lines of Platt, Subba Rao, and Denman (1977), utilizing natural assemblages of phytoplankton containing *Nitzschia*; and through manipulation of the environmental conditions, monospecific blooms of this diatom would be induced. Levels of domoic acid in the algae will be determined.

2. Long-Term Objectives:

Establish the conditions that would be necessary to induce the development of toxic algal blooms in natural assemblages of phytoplankton samples maintained in laboratory cultures. Utilize algal cultures as analogues of natural blooms in a study of phycotoxin production with a view to predict the occurrence of toxic algal blooms.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Obtain bulk quantities of seawater from monitoring stations with low concentrations of toxin-producing algae, and through perturbation techniques induce blooms.

All the necessary gear for the microcosm was fabricated to our specifications and obtained. Experiments utilizing bulk seawater samples could not, however, be carried out due to a shortage of contractual technical help.

2. Investigate the physiological ecology of these blooms with an emphasis on the production of toxins.

See above.

3. Continue investigations on the physiology of domoic acid production by *Nitzschia pungens* isolates and other species of *Nitzschia* grown under a variety of stresses.

Brought into culture several other strains of *N. pungens* f. *multiseriis*. Continued investigations on the physiology of domoic acid production by *Nitzschia pungens* isolates and other species of *Nitzschia* grown under a variety of stresses and in chaemostats.

4. Additional Accomplishments:

1. Completed the analysis of bloom samples of *Dinophysis norvegica* and *Gonyaulax digitale* from the Bedford Basin.
2. Analyzed phytoplankton data from a monitoring program off Nova Scotia.

3. Designed, and had installed, a new walk-in culture laboratory.
4. Completed a domoic acid flux model in *Mytilus* populations.

5. Goals/Expected Outputs for 1992:

1. Continue investigations on the physiology of isolates of *Nitzschia pungens* f. *multiseriata* and *N. pseudodelicatissima* domoic acid production.
2. Prepare several manuscripts for scientific journals on *Dinophysis norvegica*, phytoplankton distributions, and physiological ecology of *N. pungens* f. *multiseriata*.
3. Set up laboratory-scale experimental microcosms similar to Vat immersion core illumination incubator (Wohlgemuth, Subba Rao, and Mann 1991 [in press]) in tanks with circulating seawater from Bedford Basin. Fill the microcosms with seawater collected from Digby station and set up a nutrient gradient by spiking techniques. Monitor phytoplankton composition and species succession patterns to determine conditions necessary for the inducement of *Nitzschia* blooms.
4. Continue the present sampling protocol seasonally and through the various growth phases of blooms and determine domoic acid levels.
5. Continue analyses of data from the phytoplankton monitoring program in collaboration with Physical and Chemical Sciences Branch (PCS) scientists with a view to bring to publication.

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

Collaborated with Dr. Li and Dr. Warnock (BOD, BSB) on the physiological studies of *Nitzschia pungens* f. *multiseriata*.

Collaborated with Dr. Sinclair (Director, BSB) and Mr. Wilson (Contractor) in preparing an overview paper on the biological oceanography of the Gulf of Maine.

Collaborated with Dr. W. Silvert (HED, BSB) in developing a dynamic model of the flux of domoic acid through *Mytilus edulis* population of Cardigan Bay.

It is proposed to collaborate with Dr. P. Yeats (Marine Chemistry Division, PCS) on nutrient analyses in connection with the microcosm perturbation studies.

ii. University Liaison -

Continued as a thesis supervisor for Mr. Y. Pan, a Ph.D. student (Dalhousie University), working on the physiological ecology of *Nitzschia pungens* f. *multiseriata*.

Under Dr. Durvasula's supervision, an M.Sc. thesis on the uptake and loss of neurotoxin domoic acid by mussels (*Mytilus edulis*) and scallops (*Placopecten magellanicus*) was awarded to Mr. G. Wohlgemuth by Dalhousie University.

Supervised a Ph.D. research project of Mr. K. Kumarsingh's (University of West Indies) on environmental effects of pollution.

iii. Communications -

iv. Contracts Administered -

G. Wohlgemuth: Maintenance and culturing of algae for phycotoxin study - \$15.0 K.

v. Other -

7. Publications:

i. Primary -

Pan, Y., D.V. Subba Rao, and R.E. Warnock. 1992. Photosynthesis and growth of *Nitzschia pungens* f. *multiseriata* Hasle, a neurotoxin-producing diatom. *J. Exp. Mar. Biol. Ecol.*: in press.

Silvert, W.L., and D.V. Subba Rao. 1992. Dynamic model of the flux of domoic acid, a neurotoxin, through *Mytilus edulis* population of Cardigan Bay, P.E.I. *Can. J. Fish. Aquat. Sci.* 49: in press.

Wohlgemuth, G., D.V. Subba Rao, and K.H. Mann. 1992. Vat incubator with immersion core illumination - a new inexpensive set-up for mass phytoplankton culture. *J. Applied Phycology*:

accepted.

Amadi, I., D.V. Subba Rao, and Y. Pan. 1991. Red water: *Gonyaulax digitale* bloom in the Bedford Basin, Nova Scotia, Canada. Mar. Biol.: submitted in August 1991.

Subba Rao, D.V., F. Partensky, G. Wohlgeschaffen, and W.K.W. Li. 1991. Flow cytometric and microscopic study of gametogenesis in *Nitzschia pungens* (Bacillariophyceae) a toxic, bloom-forming, marine diatom. J. Phycol. 27: 21-26.

ii. Interpretive Scientific -

Sinclair, M., S. Wilson, and D.V. Subba Rao. 1992. Overview of the biological oceanography of the Gulf of Maine, p. 1-24. In: Proceedings of the Conference on the Gulf of Maine Coastal Zone Management (Woods Hole, Mass., U.S.A.): in press.

Subba Rao, D.V. 1992. Ocean sciences: Mariculture in developing countries. Keynote address IAPSO Symposium PS02, CODC, XX General Assembly IUGG (August 1991, Vienna): in press.

Subba Rao, D.V. 1991. Recent observations of toxic dinoflagellate blooms in Atlantic Canadian waters. Proceedings of the Canadian Workshop on the Risk to Canada's Marine Resources of Species Introductions Carried in Ships' Ballast Water (April 1991, Dartmouth, N.S.): in press.

iii. Scientific and Technical -

Subba Rao, D.V. 1992. Lessons from phytoplankton monitoring program in Nova Scotia coastal waters. Proceedings of the Fifth International Conference on Toxic Marine Phytoplankton (October 28 to November 1, 1991, Rhode Island, U.S.A.): in press.

Pan, Y., D.V. Subba Rao, and K.H. Mann. 1992. Proximate composition of *Nitzschia pungens* f. *multiseriis*. Proceedings of the Fifth International Conference on Toxic Marine Phytoplankton (October 28 to November 1, 1991, Rhode Island, U.S.A.): in press.

Pan, Y., D.V. Subba Rao, K.H. Mann, W.K.W. Li, and R.E. Warnock. 1992. Temperature dependence of growth and carbon assimilation in *Nitzschia pungens* f. *multiseriis* Hasle, the causative diatom acid poisoning. Proceedings of Fifth International Conference on Toxic Marine Phytoplankton (October 28 to November 1, 1991, Rhode Island, U.S.A.): in press.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project remains very productive. It should be noted that it has no permanent technical support. Support is supplied by contract. This project also involves excellent university collaboration. It will be reviewed in the 1992 phycotoxin peer review exercise.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 704

Section:

Project Title: Coastal Phytoplankton Dynamics

Project Leader: Keizer, P.D.

Other Researchers: Durvasula, S.R.; Orr, E.A.

Work Activity: W.A.1.1.3.2

Key Words: phytoplankton; toxic algae; phycotoxin; habitat research

1. Project Description:

Three kinds of shellfish toxins occur in the marine environment of the Maritime provinces: Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP) and Diarrhetic Shellfish Poisoning (DSP). These toxins are produced by phytoplankton and/or associated microorganisms. Under this project, water samples are collected on a regular and frequent basis at five coastal locations near aquaculture facilities along the Atlantic and Fundy coasts of Nova Scotia. Phytoplankton species present are identified and enumerated. In addition, a variety of physical and chemical variables (light, temperature, salinity, SPM, chlorophyll, nutrients, etc.) are measured at the study sites. Water samples are also returned to the laboratory for culture studies.

This project is part of an Atlantic Zone program involving the Québec, Gulf, and Newfoundland Regions as well as the St. Andrews Biological Station.

2. Long-Term Objectives:

Establish a database of the quantitative and qualitative abundance of phytoplankton in coastal sites around Nova Scotia with a view to understanding which environmental variables such as currents, tidal exchange, light, temperature, nutrients and certain trace elements contribute to the growth and blooming of algae with special attention to toxin-producing species.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. The sampling of the Nova Scotian sites for physical oceanographic, chemistry, and plankton data will continue under contract. Existing data will be reviewed to ensure that necessary refinements are made to existing protocols. (Keizer)

Due to logistic problems the Woods Harbour, N.S., site was discontinued. Sample collection at the other four sites continued up to the middle of December with a brief disruption in September due to the PSAC strike. The protocol for analysis of samples for ammonia and urea was changed to insure sample integrity.

2. Data for salinity, temperature and *in vivo* fluorescence will be collected with the SeaBird 25 at each site. Water samples will be analyzed for salinity, extracted chlorophyll and phaeophytin, nitrate, silicate and phosphate at BIO. Analysis for ammonia and urea will be done under contract. (Bugden, Yeats, Keizer)

As above.

3. Samples for phytoplankton identification and enumeration will be handled under contract. (Durvasula)

As above.

4. The annual data bases will be combined into a single, more powerful data base management system and regular reports will be issued to interested parties. (Keizer)

The discrete sample data are now accessible through a FoxPro 2.0 relational data base management system. Two interim data reports were prepared for each of the stations and distributed to interested parties. A third and final report is in preparation.

5. Staff of the Inspection Services Branch will be trained in the identification of potentially toxic algae in water samples. (Durvasula)

One staff member from the Inspection Services Branch was trained in the identification of potentially toxic algae in water samples.

6. Preliminary analysis of the data collected to date will be completed for presentation at the annual Canadian Workshop on Harmful Marine Algae. (Durvasula)

No workshop was held this year. However, a paper was prepared and presented at the 5th International Phytoplankton Conference in Providence (Rhode Island, U.S.A.) and will be published in the proceedings.

7. Wherever possible, samples for phytoplankton identification and enumeration should be collected using ships of opportunity on Georges Bank. (Durvasula)

Samples were obtained from one cruise to Georges Bank and are presently being processed.

#### 4. Additional Accomplishments:

1. Preparation of an article describing the program for the BIO biennial review.

#### 5. Goals/Expected Outputs for 1992:

1. The complete database for the first three years will be given to the end users early in 1992, as soon as the data from the last stations in December are entered and some quality control tests are conducted on the data base. (Keizer, Orr)
2. A technical report will be prepared summarizing the data collected at the five sites from 1989 to 1991. (Keizer, Orr, Bugden, Yeats, Durvasula)
3. Continue the present sampling protocol at one location (and perhaps more) to provide a long-term record of the variability of the measured variables. Sample collection, phytoplankton identification, and ammonia and chlorophyll analyses will be done under contract. (Keizer, Bugden, Durvasula, Yeats)

#### 6. Background:

##### Highlights:

Completed initial three-year sampling period in December 1991 (over 1300 samples on 439 sampling dates).

##### Selected Involvements:

##### i. Collaborative Research -

G. Bugden, Coastal Oceanography Division (PCS)  
P. Yeats, Marine Chemistry Division (PCS)  
W. Watson-Wright, Inspection Services Branch  
M. Gilgan, Inspection Services Branch

##### ii. University Liaison -

##### iii. Communications -

##### iv. Contracts Administered -

Sprytech Biological for the collection and processing of water samples from five sites along the Nova Scotian coastline (DSS File No. OSC90-00579-(011)). (Keizer)

Phyllis Butts for the identification and enumeration of phytoplankton in seawater samples (DSS File No. OSC90-00544-(008)). (Durvasula)

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

Subba Rao, D.V. 1992. Lessons from phytoplankton monitoring programme in Nova Scotian coastal waters. Proc. Fifth International Conf. Toxic Marine Phytopl. (Oct. 1991, Rhode Island).

##### iv. Popular and Miscellaneous -

Phytoplankton monitoring program interim reports for (1) Torbay, (2) Ship Harbour, (3) St. Margarets Bay, (4) Woods Harbour, and (5) Digby. Two sets of reports issued, one in May and the other in October of 1991.

#### 8. Review and Evaluation:

This project has accumulated a large body of environmental data. Excellent progress has been made in establishing a database management system so the data can be accessed efficiently and analyzed. It is important that these data are now analyzed and prepared for publication on a multidisciplinary basis. Further discussion is needed on the degree to which this project should continue now that the initial three-year period is completed. This will take place during the 1992 phycotoxin peer review exercise.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 705

Section:

Project Title: Kelp and Seagrass Habitat Studies

Project Leader: Mann, K.H.

Other Researchers: Durvasula, S.R.

Work Activity: W.A.1.1.3.1

Key Words: kelp; marine plants; primary production; domoic acid; habitat research

1. Project Description:

Long-term studies on the role of seaweed and seagrass beds as habitats for invertebrate animals in the coastal zone of Nova Scotia. Particular attention to the origin and fate of domoic acid in coastal zone food webs.

2. Long-Term Objectives:

Understand the role of kelp beds (Laminaria and Agarum spp.), intertidal seaweeds (Fucus and Ascophyllum), and seagrass (Zostera) in providing habitat for the invertebrate food web of coastal waters, including commercial species such as lobsters, scallops, and shrimps; and understand the role of sea urchins, which have the ability to destroy kelp beds; understand the environmental factors controlling the production of domoic acid by Nitzschia and the mechanism of its transfer to mussels.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare and submit for journal publication one further paper on the response of invertebrates to the disturbance of a seagrass bed by ice rafting. (Schneider, Mann)

A paper "Rapid Recovery of Fauna Following Simulated Ice Rafting in a Nova Scotian Seagrass Bed" was accepted by Marine Ecology Progress Series and will appear in late 1991 or early 1992. It was shown that the fauna of a seagrass bed recovers from ice disturbance more rapidly than the seagrass itself. The patches from which seagrass is removed are rapidly colonized by floating macroalgae, which provide a temporary habitat for the fauna.

2. Prepare and submit for journal publication a paper on the uptake of domoic acid by mussels. (Wohlgeschaffen, Durvasula, Mann)

One paper on the methods used in this study "Vat Incubator With Immersion Core Illumination - A New, Inexpensive Set-Up for Mass Phytoplankton Culture" was accepted by the Journal of Applied Phycology on October 21, 1991. A second paper on the definitive results of the study should be ready before the end of 1991. It will be shown that uptake of domoic acid by mussels in the laboratory can take place at a rate commensurate with field observations, once the technical problems of culturing large quantities of Nitzschia pungens have been solved.

3. Continue to advise Ph.D. student, Y. Pan, on ecological aspects of his investigation into the factors governing the production of domoic acid by the diatom Nitzschia pungens.

Y. Pan has continued to make good progress toward his objectives.

4. In collaboration with Dr. N. Hagen (Institute of Fisheries and Aquaculture, Bodo, Norway), prepare a paper for journal publication on the factors influencing destructive grazing of kelp beds by sea urchins.

A paper "Functional Response of the Predators American Lobster, Homarus americanus (Milne-Edwards), and Atlantic Wolffish, Anarhichas lupus (L.), to Increasing Numbers of Green Sea Urchin, Strongylocentrotus droebachiensis (Müller)," has been submitted to the Journal of Experimental Marine Biology and Ecology. It shows that in controlled laboratory experiments, lobsters preyed upon sea urchins at rates that are consistent with the hypothesis that green sea urchin outbreaks may be triggered by reductions in predation pressure.

5. Complete editing, indexing, and proofreading for the book Fundamentals of Aquatic Ecology.

The book was published in early October 1991.

#### 4. Additional Accomplishments:

1. Publication of the book: Mann, K.H. and J.R.N. Lazier, Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans. This was the output of Project 717, which is now discontinued.
2. Publication of the paper "Herbivore-Like Damage Induces Increased Strength and Toughness in a Seaweed" in the Proceedings of the Royal Society of London. This was listed as an objective several years ago, but publication was delayed by more urgent priorities of the senior author (Dr. R.B. Lowell).
3. Publication of two book reviews, one of "Enclosed Experimental Ecosystems: A Review and Recommendation," edited by Carol Lali; and the other of "Seaweeds: Their Environment, Biogeography, and Ecophysiology," by K. Lüning.

#### 5. Goals/Expected Outputs for 1992:

1. In collaboration with Dr. N. Hagen (Institute of Fisheries and Aquaculture, Bodo, Norway), prepare and submit for publication a further paper on the role of predators in controlling numbers of the green sea urchin, which is capable of destroying kelp habitats.
2. In collaboration with G. Wohlgeschaffen and Dr. S.R.V. Durvasula, prepare and submit for publication a further paper on the conditions under which mussels take up domoic acid from the diatom *Nitzschia pungens*.
3. In collaboration with Dr. S.R.V. Durvasula, supervise a student involved in the investigation of the uptake of domoic acid from cultures of *Nitzschia pungens* by mussel larvae.
4. Act as associated editor for a volume reporting the proceedings of a scientific conference on "Benguela Trophic Functioning" (September 8 to 13, 1991, Cape Town, South Africa).
5. Respond to the invitation of the General Secretary of the International Council for the Exploration of the Sea (ICES) to present the traditional "Open Lecture" at the opening session of the General Assembly of ICES (September 24, 1992, Germany).
6. Negotiate with Blackwell Scientific Publications Ltd. for the publication of a revised and updated version of my monograph Ecology of Coastal Waters: A Systems Approach, first published in 1982.

#### 6. Background:

##### Highlights:

This work is a continuation of a long and fruitful study of coastal zone habitats, jointly with Dalhousie University students, some of whom are now in employment abroad.

##### Selected Involvements:

##### i. Collaborative Research -

Collaboration with university personnel (see Section 6ii).

##### ii. University Liaison -

All of the above research is funded mainly by the Natural Science and Engineering Research Council (NSERC) and is carried out collaboratively with Dalhousie University personnel: N. Hagen (recently completed Ph.D.), F. Schneider (recently completed Ph.D.), and G. Wohlgeschaffen (recently completed M.Sc.).

##### iii. Communications -

Seminar at Dalhousie University, Department of Oceanography: "Effects of Physical Factors on Ecological Processes: How Important are They?" Lectures to International Oceans Institute, Dalhousie University: "Factors Affecting the Distribution of Global Fisheries Resources."

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Lowell, R.B., J.H. Markham, and K.H. Mann. 1991. Herbivore-like damage induces strength and toughness in a seaweed. *Proc. R. Soc. Lond. B* 243: 31-38.

Schneider, F.I., and K.H. Mann. 1991. Species-specific relationships of invertebrates to vegetation in a seagrass bed. I. Correlational studies. *J. Exp. Mar. Biol. Ecol.* 145: 101-117.

Schneider, F.I., and K.H. Mann. 1991. Species-specific relationships of invertebrates to vegetation in a seagrass bed. II. Experiments on the importance of macrophyte shape, epiphyte cover and predation. *J. Exp. Mar. Biol. Ecol.* 145: 119-139.

## ii. Interpretive Scientific -

Barnes, R.S.K. and K.H. Mann (eds.). 1991. Fundamentals of aquatic ecology. Blackwell Scientific Publications (Oxford): 270 p.

Mann, K.H. 1991. Organs and ecosystems, p. 3-28. In: R.S.K. Barnes and K.H. Mann (eds), Fundamentals of aquatic ecology. Blackwell Scientific Publications (Oxford).

Mann, K.H., and J.R.N. Lazier. 1991. Dynamics of marine ecosystems: Biological-physical interactions in the ocean. Blackwell Scientific Publications (Boston): 466 p.

## iii. Scientific and Technical -

Mann, K.H. 1991. Review of C.M. Lalli (ed.) 1990. Enclosed experimental ecosystems: A review and recommendation. Quart. Rev. Biol. 66: 221.

Mann, K.H. 1991. Review of K. Lüning 1990. Seaweeds: Their environment, biogeography and ecophysiology. Limnol. Oceanogr. 36: 1066.

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to be very productive and benefits from excellent university collaboration.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 707

Section:

Project Title: Inshore Molluscan Habitat Studies

Project Leader: Rowell, T.W.

Other Researchers: Peer, D.L.; Woo, P.

Work Activity: W.A.1.1.3.1

Key Words: clams; habitat research

1. Project Description:

This project involves basic biological and ecological research necessary for the management of the inshore molluscan habitat resources of the Scotia-Fundy Region. Research is directed at defining those biological and ecological parameters of key importance in the life cycle and productivity of inshore molluscs with the objective of providing scientific advice to fisheries habitat managers, fishermen, and aquaculturists.

2. Long-Term Objectives:

Develop scientific information on the biology and ecology of inshore molluscan shellfish resources and their habitat in order to optimize their production and define their importance to the productivity of inshore communities; and provide timely and scientifically sound advice to management.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continuation of studies evaluating environmental changes in the Annapolis Basin, their relationship to man-made structures such as the causeway and hydro-electric facility, and their impact on soft-shell clam production. The apparent "reconditioning" of the flats and rebuilding of clam populations in the upper Basin will be monitored and collaborative studies with scientists in AGC and at Dalhousie, Acadia, and Liverpool Universities continued. (Rowell)

A study of the magnetic properties of surficial and sub-surface sediments throughout the Annapolis Basin, carried out in collaboration with AGC and Liverpool University, had, in 1990, produced results suggesting that the Annapolis Tidal Power facility did change the distribution and nature of surficial sediments in the upper area of the Basin and was likely a key factor in the decline of the soft-shell clam population. It had been planned to continue with this avenue of investigation, with further typing of sediments and their movements, but hopes for funding under the Green Plan did not materialize this year. This study will be reactivated should funding become available in FY 1992/93. Further sampling of established transects was carried out to monitor soft-shell clam settlement, survival, and growth (see #2 below). For the third consecutive year, a heavy settlement took place over the Oak Point area where, in the years from 1982 to 1988, surface sediments appear to have blocked settlement or survival. One primary publication bearing on both the environmental and biological aspects of the Annapolis Basin clam population decline was produced.

2. Continuation of studies into factors influencing soft-shell clam settlement, growth, and mortality which have direct relevance to habitat management and possible means of enhancing productivity of the flats. Emphasis will focus primarily on factors influencing clam settlement and the subsequent distribution and survival of juveniles. Predator/prey studies will be continued with the aim of evaluating the degree to which Mya is preferentially preyed upon by Cerebratulus and the relative importance of this and other predators in relation to clam mortalities. (Rowell)

Carried out sampling of 1990 year-class (juveniles) of soft-shell clams to further evaluate distribution patterns relative to area of the Annapolis Basin, level on intertidal, and sediment type and followed growth and survival of the 1989, 1990, and 1991 year-classes at Oak Point. These year-classes are the first to settle and survive over large areas of the upper Basin since 1981. A major increase in the abundance of the nemertean Cerebratulus lacteus from 1989 to 1990 was taken to be a reflection of the general availability of 1989 year-class clams of suitable prey size in 1990. Continued high abundance of C. lacteus in 1991, when both 1989 and 1990 year-classes of Mya were available as prey, adds support to this hypothesis. The growth and mortality study, including both natural and clam hack induced mortality, of small juveniles (2-10 mm) was also continued. Results indicate that mortality rates are very high among juveniles during their second year. Juveniles of this size and age were also found to suffer much higher mortalities as a result of clam digging activities than had previously been demonstrated for clams 13-19 mm in length. Length frequencies of known-age clams in the Annapolis Basin indicate very high growth rates; some reaching 41 mm within 2 years. These same data suggest that age determinations based on shell "growth" lines may be in error by 1 or possibly 2 years. A number of experiments were carried out to further determine the role of C. lacteus as a predator of bivalve molluscs. These confirmed that Mya is among its preferred prey, and that Macoma is also a major prey. The razor clam Ensis was also shown to be a prey of C.

lacteus, but was only taken after all Mya and Macoma had been consumed. This was shown to be due, in part, to the high mobility of Ensis providing it an effective escape mechanism. Mytilus was shown not to be a prey of C. lacteus. This may be a result of its epibenthic habitat, as we have observed that C. lacteus will not attack even Mya when this species is kept exposed on the bottom substrate. Studies on the partitioning, based on size, of the soft-shell clam prey resource between the spotted moon shell, Lunatia triseriata, and the northern moon shell, L. heros, could not be carried out due to difficulties in obtaining sufficient numbers of L. heros. Support and guidance are being provided to a doctoral student at Dalhousie University in studies of factors influencing the initial settlement of larval clams and the subsequent, often quite different, distribution of juveniles (and, in consequence, adults).

3. Continuation of the Clam Enhancement Project, analysis and evaluation of its outputs, provision of biological advice for the implementation, and evaluation of soft-shell clam enhancement activities both underway and newly undertaken (eastern shore) by DFO and various clam fishermen's associations. Under this goal there will continue to be considerable collaboration with the clam assessment biologist (S. Robinson) at St. Andrews, N.B., including analysis and publication of some elements of the project. (Rowell)

Due to cancellation of the DFO Development Program, some elements of the project were discontinued and all others scaled down in this, the fourth of the planned 5 years established for it. All research components not directly related to stock and fishery assessment or to the analysis of fishermen's field enhancement trials were cut from the project. In addition, the field collection of assessment data was severely curtailed. Despite the shortened duration of the project, an otherwise unattainable data base has been developed; and it is certain that this data base, and the scientific findings resulting from other aspects of the project, will be of great benefit to future management of the resource.

4. Provision of advice on the inshore clam fishery for the Atlantic coast, and where appropriate, collaboration with the Bay of Fundy clam biologist (S. Robinson) in the provision of advice on a Regional basis. (Rowell)

Advice was provided to a number of Southwestern and Eastern Nova Scotia Clam Advisory Committee meetings with respect to management of the resource and in relation to the established clam enhancement projects being conducted by fishermen's groups in Five Islands, Economy, Thornes Cove, and the southern and northern shores of the Annapolis Basin.

5. Preliminary analysis and possible publication of historical soft-shell clam population data for the Annapolis Basin. (Rowell, Woo)

No progress was possible due to other tasks being of higher priority and to the project leader's assumption of responsibility for Project No. 710 (Benthic Habitat Studies) and for the current AFAP study into the impact of trawling on the benthos.

6. Publication of reports and papers on some or all of the following: predation of the nemertean worm C. lacteus on M. arenaria and the importance of M. arenaria relative to other prey items (Rowell); the indirect effects of clam digging on the viability of small (2-10 mm) juvenile clams (Rowell); analysis and reporting of the biological and fisheries assessment components of the Clam Enhancement Project (Rowell, Robinson); recent erosion and deposition patterns in the Annapolis Basin as revealed by magnetic properties of the sediments. (Rowell, Amos, Oldfield)

Five primary publications were published: one on predation of the nemertean worm C. lacteus on M. arenaria, one on the effects of trawling, dredging, and ocean dumping on the eastern Canadian continental shelf, one on the control of soft-shell clam recruitment by bedload sediment transport, one on the indirect mortality effects of clam digging, and one on the effects of sediment on clam physiology and growth.

#### 4. Additional Accomplishments:

1. Assisted in the final design and implementation of a study of the impact of otter trawling on bottom sediments and the benthos of offshore environments on the Grand Bank and the Scotian Shelf.
2. Participated in a number of Southwestern and Eastern Nova Scotia Clam Advisory Committee meetings with respect to management of the resource and in relation to the established clam enhancement projects being conducted by fishermen's groups in Five Islands, Economy, Thornes Cove, and the southern and northern shores of the Annapolis Basin.
3. Provided on-site guidance and assistance to the above-noted fishermen's groups in the conduct of their enhancement activities.
4. Participated on the Annapolis Basin Working Group.
5. Participated on the Scotia-Fundy Regional Shellfish Committee.
6. Participated on the Non-Indigenous Species Introductions Committee.
7. Prepared a display on the impact of tidal power, in conjunction with nemertean predation, on the Annapolis Basin clam population for the DFO display at Digby Scallop Days (Aug. 9-11, 1991, Digby, N.S.).
8. Presented a talk entitled "Destruction of a Clam Population through Environmental Change and Predation" to the Halifax Field Naturalists (Aug. 1, 1991, Halifax, N.S.).
9. In response to a request from DFO's Gulf Region, carried out a field investigation and conducted two predation experiments to determine the possible role of C. lacteus in mortalities of the bay quahaug Mercenaria mercenaria. C. lacteus was found not to be a predator of M. mercenaria.

## 5. Goals/Expected Outputs for 1992:

1. Continuation of studies evaluating environmental changes in the Annapolis Basin, their relationship to man-made structures such as the causeway and hydro-electric facility, and their impact on soft-shell clam production. The apparent 'reconditioning' of the flats and rebuilding of clam populations in the upper Basin will be monitored and collaborative studies with scientists in AGC and at Dalhousie, Acadia, and Liverpool Universities continued. (Rowell)
2. Continuation of studies into factors influencing soft-shell clam settlement, growth, and mortality which have direct relevance to habitat management and possible means of enhancing productivity of the flats. Emphasis will focus primarily on factors influencing clam settlement and the subsequent distribution and survival of juveniles. Predator/prey studies will be continued with the aim of evaluating the degree to which Mya is preferentially preyed upon by Cerebratulus and the relative importance of this and other predators in relation to clam mortalities. (Rowell)
3. Continuation of analysis and evaluation of outputs of the Clam Enhancement Project and the provision of biological advice for implementing and evaluating longer term soft-shell clam enhancement activities by various clam fishermen's associations. Under this goal there will continue to be considerable collaboration with the clam assessment biologist (S. Robinson) at St. Andrews, N.B., including analysis and publication of some elements of the project. (Rowell)
4. Publication of reports and papers on some or all of the following: predation of the nemertean worm C. lacteus on M. arenaria and the importance of M. arenaria relative to other prey items (Rowell); the indirect effects of clam digging on the viability and growth of small (2-10 mm) juvenile clams (Rowell); analysis and reporting of the biological and fisheries assessment components of the Clam Enhancement Project (Rowell, Robinson); and, should funding be available, recent erosion and deposition patterns in the Annapolis Basin as revealed by magnetic properties of the sediments. (Rowell, Amos, Oldfield)

## 6. Background:

### Highlights:

As in 1989 and 1990, the progress made in the implementation of the Clam Enhancement Project and the successful conduct of the field trials by the fishermen involved were one highlight of the project. Despite the withdrawal of support for the basic research component of our studies early in the year, analysis and write-up of elements of this component continued in a highly productive manner, furthering our understanding of the general ecology of soft-shell clams and providing new knowledge immediately applicable to the management of the stocks.

### Selected Involvements:

#### i. Collaborative Research -

Annapolis Basin studies continue to involve contact with and coordination of efforts with an assortment of DFO scientists and operations people (Fisheries and Habitat Management Branch) as well as The Department of Energy, Mines and Resources (Atlantic Geoscience Centre), the Canadian Hydrographic Service, Acadia University (Estuarine Research Centre), Dalhousie University (Department of Oceanography), and Liverpool University (Department of Geography).

#### ii. University Liaison -

Dalhousie University (Department of Oceanography) - J. Grant and C. Roegner on studies of factors influencing the initial settlement of larval clams and the subsequent distribution of juveniles and adults. Serving on C. Roegner's PhD committee.

Liverpool University (Department of Geography) - F. Oldfield on 'fingerprinting' Annapolis Basin sediments by their magnetic properties and determining the source of sediments covering formerly productive clam flats in the upper Basin. Further collaboration dependent on available funding.

#### iii. Communications -

#### iv. Contracts Administered -

Dalhousie University - for the provision of contract services by T. McLane for the conduct of field and analytical operations under the Clam Enhancement Project - \$32.5 K.

#### v. Other -

## 7. Publications:

### i. Primary -

Emerson, C.W. and J. Grant. 1991. The control of soft-shell clam (Mya arenaria) recruitment on intertidal clam flats by bedload sediment transport. *Limnol. Oceanogr.* in press.

Emerson, C.W., J. Grant, and T.W. Rowell. 1990. Indirect effects of clam digging on the viability of soft-shell clams, Mya arenaria L. Neth. J. Sea Res. 27(1): 109-118.\*

Grant, J. and B. Thorpe. 1991. The effects of suspended sediment on the growth and physiology of the soft-shell clam (Mya arenaria). Can. J. Fish. Aquat. Sci. 48 : 1285-1292.\*

Messieh, S.N., T.W. Rowell, D.L. Peer, and P. J. Cranford. 1991. The effects of trawling, dredging, and ocean dumping on the eastern Canadian continental shelf. Cont. Shelf Res. 11(8-10): 1237-1263.

Rowell, T.W. 1991. Destruction of a clam population (Mya arenaria Linné) through the synergistic effects of habitat change and predation by a nemertean (Cerebratulus lacteus Verril). Proc. 25<sup>th</sup> Europ. Mar. Biol. Symp.: in press.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

#### 8. Review and Evaluation:

Despite the loss of much of the funding, this project continues to be very productive. It has been proposed that stock assessment and management duties for Atlantic coast clams be transferred to another Division.

\* Work supported under the Clam Enhancement Project.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 708

Section:

Project Title: Scallop Habitat Research

Project Leader: Cranford, P.J.

Other Researchers: Gordon, D.C.; Keizer, P.D.

Work Activity: W.A.1.1.3.2

Key Words: scallops; contaminants; habitat research; near-bed particle field; particle transport

1. Project Description:

Study the interaction between scallops (*Placopecten magellanicus*), their trophic resources and potential contaminants, and relate to habitat quality. Characterize the near-bed particle field under natural conditions in productive scallop habitats. Develop techniques to study and monitor the dispersion, dynamics, and benthic boundary-layer transport of petroleum exploration and production of operational discharges offshore. Investigate the potential impact zone of operational discharges with regard to: 1) the near-bed particle field; 2) the nature of available particulate food resources; and 3) the sublethal impacts on scallop growth, reproduction, and physiology.

2. Long-Term Objectives:

Identify processes which underlie scallop production and reproduction and determine critical variables. Provide predictive relationships for scallop production and reproduction as a function of environmental variables and stresses with emphasis on the quality of organic seston, the dynamics of the near-bed water column, and the impact of potential contaminants.

Identify the ecological consequences of discharged wastes associated with hydrocarbon exploration and production on the commercially important Georges Bank scallop stocks by providing input into proposed modelling efforts aimed at estimating the size and duration of impact zones around drilling rigs. Provide methodology for routine monitoring of drilling discharges and their dispersion.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete analysis of Georges Bank cruise data on scallop feeding and digestion and combine with studies on sediment carbon transport (J. Grant, Dalhousie University), seston flux over seabed (D.K. Muschenheim), and current data (J. Loder, OCD, PCS) to prepare a paper on sediment resuspension, organic quality and its utilization by sea scallops on Georges Bank. Also use data from Georges Bank to assess the contribution of sea scallops to benthic metabolism and nutrient regeneration on Georges Bank. (Cranford)

Data collation and analysis is currently in progress. This project was delayed by other priorities; however, the first manuscript should be submitted for publication by the end of the year. The scope of the second paper is being expanded to assess the contribution of all macrobenthic suspension-feeding bivalves to benthic metabolism, phytoplankton consumption, and nutrient regeneration on Georges Bank. B.T. Hargrave will include data on particle sedimentation rates on Georges Bank. Results of these data are also being used in an overview paper on the influence of physical processes on the biological productivity of the Bank.

2. Conduct PERD-funded research on the effects of drilling wastes on adult sea scallops. (Cranford, Gordon)

Long- and short-term studies of the sublethal effects of two major operational drilling wastes (bentonite and barite) were conducted. Results of the influence of relatively dilute concentrations of bentonite clay on scallop feeding activity and tissue growth were presented at the 26<sup>th</sup> European Marine Biology Symposium (September 17-22, 1991, Middleburg, The Netherlands) and will be published in the proceedings. Other physiological (digestion, respiration, and excretion) and tissue growth data are currently being analyzed for both exposures. Samples of used water-based drilling muds were collected from a working well off Nova Scotia and will be used in several exposures, starting in January.

3. Integrate data on physiological responses of sea scallops to bentonite clay into a model that will estimate the effect of any given concentration of suspended clay and exposure period on scallop growth. (Cranford, Keizer)

Sample and data analysis is underway, and a draft manuscript should be ready by the end of the year.

4. Conduct preliminary studies on the nutritional significance of the dissolved organic matter pathway using juvenile sea scallops as test organisms. (Cranford, Mann)

The demands of other projects precluded initiation of this study at this time.

5. Complete the modifications to BOSS and test the improved device prior to deployment on Georges Bank. (Muschenheim)

Modifications to increase the sample volumes taken during BOSS sampling were completed in the Metrology mechanical development shop in early August, after several months of prototype fabrication and testing. Improvements to the cocking and triggering mechanisms resulted in the extraordinarily high rate of sample recovery under difficult conditions during the August Georges Bank work.

6. Collect samples of suspended particulate matter, both in the water column and in the benthic boundary layer, around an operating drilling platform. This work depends on the opportunity afforded by LASMO Nova Scotia to sample from one of their contracted vessels, as well as the availability of a suitable lab container. (Muschenheim, Kranck, Lee)

Arrangements made through LASMO Nova Scotia resulted in the use of Secunda Marine's vessel Ryan Leet as a ship of opportunity for sampling around the jack-up rig Rowan Gorilla III for 10 days in July 1991. Prior to this, a half-size Lloyd's certified offshore container was purchased, outfitted as laboratory space, and installed on the deck of the Ryan Leet. Benthic and water column sampling gear was assembled and delivered to LASMO's dock facility for offshore shipment. Personnel from the Bedford Institute of Oceanography (Muschenheim, Cranford) and the Maurice Lamontagne Institute (Lee, Larocque) transitted by helicopter to the rig, and then transferred from the rig to the ship. Over a 10-day period nine stations were completed, with samples taken for suspended particulate matter in the benthic boundary layer and water column, as well as CTD, plankton camera, and bottom grabs. Subsamples for particle size analysis and microbial biomass and heterotrophic activity were taken and are being processed.

7. Conduct design modifications to the three "carousel" suspension tanks, allowing installation of strain gauges and the adaptation of at least one tank for a controlled temperature system. The modifications are to be completed in time for the initiation of the experimental section of the PERD-funded drilling waste flocculation project (1991-92). (Muschenheim)

PERD-funded work on flocculation of drilling muds started this year. Much time was spent in set-up and calibration of the Coulter Multisizer and the writing of specialized software. (Milligan) Modification of the carousel tanks has been deferred until next year due to the demands of Multisizer set-up and the priority of obtaining still-water settling velocities for drilling waste material and components. A complete set of carousel experiments is planned for 1992.

8. Deploy BOSS and current meter mooring(s) during the scheduled Georges Bank cruise in the summer of 1991. The cruise plan allows for stops at four stations occupied during J. Loder's PERD-funded work, as well as additional stations on Browns Bank and in the Northeast Channel. (Muschenheim, Kranck, Lee)

The planned cruise on the CSS Dawson during August 1991 was successful, with three 24 to 30 hour anchor stations completed, as well as numerous grab sample and sounder survey transects. BOSS, CTD/Niskin, plankton camera, and bottom grab samples were taken at 2-hour intervals during the tidal cycle anchor stations at both high and low scallop density sites on Georges Bank. These sites were selected in consultation with J. Loder (OCD, PCS) and G. Robert (BFAD, BSB) to assure data compatibility with other PERD-funded work. Subsamples for particle size analysis, microbial biomass and heterotrophic activity, flocculation state and organic content are currently being analyzed. Collaborative work with C. Amos (AGC, DEMR) was furthered through the participation of A. Muller (Old Dominion University) and A. Cok (Adephi University), who are testing Mr. Amos' model of sediment transport on the northern margin of the Bank.

9. Continue collaboration with C. Newell (Great Eastern Mussel Farms, Inc., Tenants Harbour, Maine) on the use of the BOSS to investigate the depletion of phytoplankton above a mussel bed. If time and equipment scheduling allow, we plan to conduct a more extensive set of field experiments in the same area. (Muschenheim)

Additional experiments on utilization of seston over mussel beds were not possible to scheduling of the LASMO and Georges Bank operations. A manuscript from the first set of experiments was prepared and has been submitted for publication.

#### 4. Additional Accomplishments:

1. A preliminary surveillance study of the effect of suspended solids on the Bull Arm (Newfoundland) scallop population was conducted. (Cranford) The study was conducted in collaboration with Dr. B.A. MacDonald (Memorial University), who has collected extensive background information on these scallops. At the time of sampling, the site was being prepared by Hibernia Development Corp. for construction of the gravity base structure and drilling platform that will be used at the Hibernia oil field.
2. P. Cranford and K. Muschenheim completed a basic survival training and M.E.D. A1 course given by Survival Systems as a prerequisite for working on offshore drilling platforms and support vessels.
3. A proposal to document inhibitory sub-lethal effects of heavy-metal contaminants and establish water quality guidelines for bivalves was prepared and submitted for funding under the Green Plan. (Cranford, Gordon, Keizer)

#### 5. Goals/Expected Outputs for 1992:

1. Continue to conduct PERD-funded research on the sublethal effects of drilling wastes on sea scallops, analyze samples, interpret data, and communicate results. (Cranford, Gordon)
2. If the Green Plan proposal is approved, develop and contract studies on the sublethal impacts of

heavy metal contaminants on sea scallops. (Cranford, Keizer, Gordon)

3. Interpret data collected from Georges Bank and publish results in terms of assessing the role of scallops and other bivalves in benthic/pelagic exchanges and the impact of sediment resuspension on diet quality. (Cranford, Hargrave, Muschenheim)
4. Conduct particle fall velocity and flocculation experiments with drilling wastes supplied from LASMO Nova Scotia operations near Sable Island. Modify and utilize carousel tanks in turbulent suspension experiments.
5. Pursue opportunities to continue sampling at Rowan Gorilla III drilling operations at the Cohasset and Panuke fields.
6. Participate in planned Metrology Division (PCS) cruise to Georges Bank site to extend benthic boundary layer current measurements and seston studies.
7. Produce a technical report on guidelines and methodology for the monitoring of particulate food supplies available to commercially important bivalve species exposed to the potential impacts of offshore hydrocarbon development.
8. Finalize plans for numerical modelling component of the PERD project. (Gordon)

#### 6. Background:

##### Highlights:

The Georges Bank PERD-funded program was commended in a recent external review and the projects are well supported by the Task 6.7 Environment Committee. Fisheries managers and industry representatives comprising the Georges Bank Steering Committee are satisfied with the approach being taken. Studies on boundary-layer particle transport are underway with two cruises designed to characterize the inorganic and organic particle fields within the benthic boundary layer of scallop grounds on Georges Bank and around an active drilling rig near Sable Island. Studies on the settling behaviour and flocculation of drilling wastes were also initiated. An assessment of the sublethal effects of operational solid drilling wastes on scallops that was initiated with A-base finding is now fully supported by PERD. Long-term exposures to two major drilling mud additives (bentonite and barite) have been conducted using a high-energy exposure protocol and the results are providing insight into the animals sensitivity to inorganic suspended solids, physiological strategies for compensation, and their recovery potential.

##### Selected Involvements:

#### i. Collaborative Research -

Attended workshops and contributed scallop data to a multidisciplinary group studying the coupling of physical and biological processes on Georges Bank. (Cranford) Scientists from several branches (BSB, PCS) and divisions of DFO and Dalhousie University are involved.

Studies at the Panuke/Cohasset site were enhanced by microbiological studies conducted by Dr. K. Lee (DFO, Maurice Lamontagne Institute). Collaboration continues with Dr. C. Amos (Atlantic Geoscience Center, DEMR) to share study opportunities. Dr. K. Kranck, T. Milligan, and B. Hartling (Coastal Oceanography Division, PCS) have been instrumental in assisting with laboratory and field studies. D. Knox and J. Conrod (Metrology Division, PCS) are continuing development work on the BOSS.

#### ii. University Liaison -

P. Cranford maintains close ties with university scientists conducting scallop research. Joint research is being conducted with Drs. J. Grant and R. O'Dor (Dalhousie University) and B.A. MacDonald (Memorial University) on basic and applied aspects of sea scallop physiology. He is serving as a committee member for masters candidate B. Vaercamer and is often called on for advice from graduate students.

D.K. Muschenheim served on the masters thesis committee for Dalhousie graduate student, J.L. Shortle, who successfully defended in July 1991.

#### iii. Communications -

P. Cranford presented results on the influence of drilling wastes on scallop growth and physiology: 1) at a meeting of the New England Estuarine Research Society (Yarmouth, N.S.); 2) at the 26<sup>th</sup> European Marine Biology Symposium (Middelburg, The Netherlands); 3) at the Habitat Ecology Division Bouillabaisse talks (BIO); 4) for the DFO Weekly Scientific Briefing; and 5) in an interview for VOXM Radio (Newfoundland). A poster and overview paper of PERD-funded research was prepared and given at the Gulf of Maine Scientific Workshop (Woods Hole, Mass.). (Cranford, Gordon, Muschenheim) A general APICS Science Lecture on Georges Bank habitat was given at the Yarmouth Museum. (Gordon) Results were communicated to industry at two meetings of the Georges Bank Steering Committee.

#### iv. Contracts Administered -

A vessel charter contract was awarded to G. Chaisson for use in Bull Arm, Nfld. - \$2.5 K

Bland Research Applications - Flocculation of drilling muds and their behaviour in the benthic boundary layer - \$55.0 K.

BDR Research Limited - Analysis of inorganic disaggregated grain size using precision Coulter Counter techniques and PDL data processing techniques - \$75.0 K.

v. Other -

Served on a steering committee that oversees the development of the DFO PERD-funded program for Georges Bank. (Cranford, Keizer, Gordon, Muschenheim) Developed contacts and coordinated research activities in Bull Arm with the Hibernia Development Corporation. (Cranford)

7. Publications:

i. Primary -

Cranford, P.J. and D.C. Gordon. 1991. Chronic sublethal impact of mineral oil-based drilling mud cuttings on adult sea scallops. *Mar. Poll. Bull.* 22: 339-344.

Grant, J. and P.J. Cranford. 1991. Carbon and nitrogen scope for growth as a function of diet in the sea scallop *Placopecten magellanicus*. *J. Mar. Biol. Ass. U.K.* 71: 437-450.

Messieh, S.N., T.W. Rowell, D.L. Peer, and P.J. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. *Cont. Shelf Res.* 11(8-10): 1237-1263.

Muschenheim, D.K., and C.R. Newell. 1991. Utilization of seston flux over a mussel bed. *Mar. Ecol. Progr. Ser.*: submitted.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This PERD-funded project is in full stride and meeting all objectives. Progress was well received by the PERD Committee in July and a funding increase request was approved. Collaboration with other scientists and industry is excellent.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 709

Section:

Project Title: Zooplankton Habitat Studies

Project Leader: Harding, G.C.

Other Researchers: Reimer, D.P.; Vass, W.P.

Work Activity: W.A.1.1.3.1

Key Words: zooplankton; lobster; organochlorines; habitat research

1. Project Description:

Study the effects of natural and anthropogenic changes on the marine pelagic community, which includes long- and short-term vagrancies of the "weather," alteration of freshwater input, contamination with pollutants, alteration of geochemical cycles, and excessive fishing.

2. Long-Term Objectives:

Undertake scientific research to provide information and advice for management of our marine environmental issues.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue data analysis and prepare papers on offshore and inshore larval lobster studies. (Harding)

The analysis of inshore and offshore larval lobster studies is progressing well. A paper has been presented to the American Society of Limnology and Oceanography meeting (June 10 to 14, 1991, Halifax, N.S.). A manuscript on larval morphometrics of inshore and offshore lobsters is in the process of being prepared for publication.

2. Complete data analysis and prepare paper on Georges Bank frontal study. (Harding)  
A poster was presented at the Gulf of Maine Scientific Workshop (January 8 to 10, 1991, Woods Hole, Mass.). A manuscript has been submitted to the journal Continental Shelf Research on zooplankton distributions at the Georges Bank frontal system. Another manuscript is being prepared on how energetic tide topography interaction controls high biological activity on northern Georges Bank in summer. (Loder, Perry, Drinkwater, Grant, Harding, Harrison, Horne, Oakey, Taggart, Tremblay, Brickman, Sinclair)

3. Continue analysis of Labrador Shelf plankton data in light of the northern cod issue and present results at a workshop in Newfoundland. (Harding)

Most of the samples were analyzed and a paper was presented at the Workshop on the Biomass Size Spectrum (March 24 to 27, 1991, St. John's, Nfld.).

4. Prepare a presentation on offshore lobster larvae results and present at a lobster workshop in Maine. (Harding)

A paper was presented at the National Shellfish Association (NSA) meeting (June 23 to 27, 1991, Portland, Maine) demonstrating the dispersion of lobster larvae off Georges Bank into the Gulf of Maine.

5. The mussel and zooplankton grazing components will be modelled in the Lunenburg mussel culture embayment. (Harding)

The field data have been collected and analyzed. A graduate student (R. Dowd) at Dalhousie University is presently modelling the food source for grazers in Upper South Cove, Lunenburg.

4. Additional Accomplishments:

1. Some of the earlier organochlorine samples (1976, 1977) from St. Georges Bay were rerun with more sophisticated, modern equipment to determine levels of the less abundant compounds. The entire data set, which includes seawater, plankton, and fish samples from 1976, 1977, 1982, and 1988, are presently being prepared for interpretation.
2. A paper was prepared on the organochlorine concentrations found in snow, seawater, plankton, and benthos of the Arctic Ocean during the 1980s.
3. An analysis of long-term vertical migration of planktonic organism was undertaken with continuous observations taken on Georges Bank over several weeks. A poster was prepared for the

American Society of Limnology and Oceanography meeting (June 10 to 14, 1991, Halifax, N.S.).

4. The relationship between wind storms and St. Lawrence River run-off and lobster landings in the Magdalen Islands was explored for the workshop "The Gulf of St. Lawrence: Small Ocean or Big Estuary" (March 1989, Mont-Joli, P.Q.).
5. Analysis of St. Margaret's Bay larval lobster study in 1983 progressed. (With R.E. Duggan)
6. The final version of the chapters on Fisheries and Oceans and coastlines for the Canadian "State-of-the-Environment" report was checked for accuracy.
7. Prepared a requested position paper on the anthropogenic effects known to affect the lobster populations (*Homarus americanus*) in the Atlantic region.
8. Provided advice and assistance to the National Research Council, Atlantic, on the mussel closure (which was effected in spring 1991) along the Atlantic coast.
9. Provided advice for a DFO working paper on our present knowledge of the relationship between the inshore and offshore lobsters neighbouring the Gulf of Maine.

##### 5. Goals/Expected Outputs for 1992:

1. Prepare a manuscript on the evidence for lobster larval dispersal from Georges Bank. (Harding, Drinkwater, Pringle, others)
2. Analyze and prepare a manuscript on the long-term trend of organochlorines in the pelagic food webs of the southern Gulf of St. Lawrence. (Harding, Addison, Hargrave, LeBlanc, others)
3. Conduct a field study to track the dispersal of patches of larval lobsters from the northwest edge of Browns Bank using Loran-C drifters and Vass-Tucker trawl. (Harding, Drinkwater, Pringle, Vass, others)
4. Prepare a manuscript on the effects of Hudson Strait outflow on the Labrador Shelf ecosystem based on changes in the biomass spectrum. (Drinkwater, Harding, others)

##### 6. Background:

###### Highlights:

Made significant advances and prepared manuscripts or presentations on: 1) The effect of convergences on the dispersion and retention of zooplankton and lobster larvae over Georges Bank, 2) the use of larval morphometrics in determining lobster stocks in the Maritimes, 3) the use of the biomass spectrum in demonstrating the lack of a hypothesized shift in organism size, from phytoplankton to fish, from north to south in the Labrador Current, and 4) analyzed organochlorine contamination in the Arctic food web in relation to global transport via the atmosphere, ocean and rivers.

###### Selected Involvements:

###### i. Collaborative Research -

R.F. Addison (MCD, PCS) - long-range atmospheric transport of organochlorines.

K.F. Drinkwater (COD, PCS) - reevaluated the possible effects of river run-off on Quebec lobster landings.

K.F. Drinkwater (COD, PCS) - retention and dispersal of larval lobster from frontal systems.

J.D. Pringle (BFAD, BSB) - larval lobster studies.

E. Ketchington, R.J. Miller (BFAD, BSB) - morphometrics of lobster larvae around the Maritimes.

K.F. Drinkwater (COD, PCS) and R. Sheldon (ESD, Science, Nfld. Region) - evaluation of the Sutcliffe hypothesis of biological production in the Labrador Current.

R.I. Perry (OES, BSB, Pacific Region) - frontal studies on Georges Bank.

###### ii. University Liaison -

S. Pearre, Jr. (Department of Oceanography, Dalhousie University) - vertical migration studies.

###### iii. Communications -

Papers presented at the Gulf of Maine Scientific Workshop (January 8 to 10, 1991, Woods Hole, Mass.), American Society of Limnology and Oceanography (June 10 to 14, 1991, Halifax, N.S.), the Workshop on the Potential Use of the Biomass Size Spectrum for Estimating Northern Cod Stocks (March 24 to 27, 1991, St. John's, Nfld.), and the National Shellfish Association (June 23 to 27, 1991, Portland, Maine).

###### iv. Contracts Administered -

E. Wilson - Georges Bank Frontal Study - \$4.0 K.

P. Butts - Georges Bank Frontal Study - \$4.0 K.  
 C. Parsons - Labrador Shelf Study - \$3.0 K.

v. Other -

## 7. Publications:

### i. Primary -

Drinkwater, K.F., G.C. Harding, W.P. Vass, and D. Gauthier. 1992. The relationship of Quebec lobster landings to freshwater run-off and wind storms. *Can. Spec. Publ. Fish. Aquat. Sci.* 113: 179-187.

Hargrave, B.T., G.C. Harding, W.P. Vass, P.E. Erickson, B.R. Fowler, and V. Scott. 1992. Organochlorine pesticides and polychlorinated biphenyls in the Arctic Ocean food web. *Environ. Contam. Toxicol.*: in press.

Perry, R.I., G.C. Harding, J.W. Loder, M.J. Tremblay, M.M. Sinclair, and K.F. Drinkwater. 1992. Zooplankton distributions at the Georges Bank frontal system: Retention or dispersion? *Cont. Shelf Res.*: submitted.

### ii. Interpretive Scientific -

Drinkwater, K.F., G.C. Harding, W.P. Vass, and D. Gauthier. 1991. The relationship of Quebec lobster landings to freshwater run-off and wind storms. *Can. Spec. Publ. Fish. Aquat. Sci.* 113: 179-187.

### iii. Scientific and Technical -

Drinkwater, K.F., G.C. Harding, and R. Sheldon. 1992. Investigating the effects of the Hudson Strait outflow on the Labrador Shelf using the biomass spectrum. *In*: M. Paranjape (ed.), *Proceedings of the Workshop on the Potential Use of the Biomass Size Spectrum for Estimating Northern Cod Stocks*. *Can. Tech. Rep. Fish. Aquat. Sci.*: in press.

### iv. Popular and Miscellaneous -

Drinkwater, K.F., J.W. Loder, and G.C. Harding. 1991. Investigations of convergence at the Georges Bank tidal front using drifting buoys. Presentation to the American Society of Limnology and Oceanography meeting (June 10 to 14, 1991, Halifax, N.S.).

Harding, G.C., J.D. Pringle, K.F. Drinkwater, A.J. Fraser, I.R. Perry, and W.P. Vass. 1991. Offshore studies of larval lobsters (*Homarus americanus*) in the Georges and Browns Banks region. Presentation at the National Shellfish Association meeting (June 23 to 27, 1991, Portland, Maine).

Harding, G.C., S. Pearre, Jr., J.D. Pringle, W.P. Vass, E. Wilson, and D.P. Reimer. 1991. Vertical migration of *Gammarus annulatus* Smith on Georges Bank. Prepared for the American Society of Limnology and Oceanography meeting (June 10 to 14, 1991, Halifax, N.S.). (Poster)

Perry, R.I., G.C. Harding, J.W. Loder, K.F. Drinkwater, and M.J. Tremblay. 1991. The Georges Bank frontal system: Mechanisms of plankton retention or dispersal. Presentation at the Gulf of Maine Scientific Workshop (January 8 to 10, 1991, Woods Hole, Massachusetts). (Poster)

## 8. Review and Evaluation:

This productive project continues on track and benefits from collaboration with many scientists.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 710

Section:

Project Title: Benthic Habitat Studies

Project Leader: Rowell, T.W.

Other Researchers: Peer, D.L.; Woo, P.; Hargrave, B.T.; Schwinghamer, P.

Work Activity: W.A.1.1.3.1

Key Words: benthos; habitat research

1. Project Description:

The benthic community is an important component of demersal fish habitats. Consequently, an understanding of its biological processes is essential to fisheries and habitat management. To that end, quantitative data on benthic invertebrate biomass, size distribution, and composition by major taxa are being collected from the coastal and shelf waters of eastern Canada.

2. Long-Term Objectives:

Measure and describe production processes of the benthic communities on the fishing grounds of Atlantic Canada. Benthic production will be related to such oceanographic processes as turbulent mixing, water depth, sedimentation and primary production, and to the production of demersal fish which feed on benthos.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Complete the sorting and identification of benthic samples from the Scotian Shelf area that have already been collected.

Several groups of samples from earlier research cruises were sorted and identified under contract.

2. Perform production calculations as data become available from the Scotian Shelf area.

Due to retirement of the principal investigator in April, this goal was unattainable.

3. Complete a publication on methods of estimating benthic production.

This work was presented at a Northern Cod Workshop (St. John's, Newfoundland). Further work by P. Schwinghamer is anticipated.

4. Participate in a Biomass Spectrum and Northern Cod Project, using size distributions from benthic fauna collected from the Labrador Sea during 1985.

Work is not yet complete, but P. Schwinghamer has the Labrador Sea macrobenthic data and is continuing to work up the meiobenthic samples.

4. Additional Accomplishments:

1. A large number of Ocean Dumping Proposals were reviewed and recommendations made.
2. Prepared and submitted Scotia-Fundy Region's input to the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries, including that to the 'Cooperative Research Report on the Effects of Marine Aggregate Extraction on Fisheries' and to the 'Code of Practice for the Commercial Extraction of Marine Minerals.'

5. Goals/Expected Outputs for 1992:

Most benthic work during 1992 will be done under the AFAP project, which is reported under project 977.

1. Continued representation of Canada on the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries and on the study group on Ecosystem Effects of Fishing Activities. (Rowell)
2. Continued analysis of earlier samples as resources permit. (Rowell)

6. Background:

**Highlights:**

In 1991, very significant progress was made in the development of improved sampling gear and in the testing of this equipment and of sampling methods and regimes during the first cruise of the trawling impact study. The highly successful cruise on the Scotian Shelf and Grand Bank has provided the basis for further gear development for use in this and future benthic studies.

**Selected Involvements:**

## i. Collaborative Research -

G. Fader and R. Miller of the Department of Energy, Mines and Resources (Atlantic Geoscience Centre), M. Chin-Yee and G. Steeves of Engineering Services and Technical Services Division (MSB), D. McKeown of Metrology Division (PCS), as well as P. Schwinghamer of DFO's Newfoundland Region and D. Marcogliese of the Maurice Lamontagne Institute (DFO, Quebec Region).

## ii. University Liaison -

## iii. Communications -

## iv. Contracts Administered -

Arenicola Marine, for the identification and enumeration of invertebrates from benthic samples (two contracts) - \$6.0 K

Maritime Testing (1985) Ltd., for molluscan sorting and identification (Dawson '91 research cruise) - \$0.9 K

## v. Other -

**7. Publications:**

## i. Primary -

Messieh, S.N., T.W. Rowell, D.L. Peer, and P. J. Cranford. 1991. The effects of trawling, dredging, and ocean dumping on the eastern Canadian continental shelf. Cont. Shelf Res. 11(8-10): 1237-1263.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

This project was seriously undermined with the early retirement of Mr. Peer and will never fully recover unless a suitable replacement can be hired. Fortunately, Mr. Rowell was able to take over as Project Leader, but his time is spread over several other projects plus administrative duties. For the coming year, most work will be done under the AFAP program (Project 977) assuming funding continues for another year.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 711

Section:

Project Title: Benthic/Pelagic Exchanges

Project Leader: Keizer, P.D.

Other Researchers: Hargrave, B.T.

Work Activity: W.A.1.1.3.1

Key Words: benthos; habitat research; aquaculture

1. Project Description:

In the environment the interfaces between phases, air-sea and sea-sediment are the sites of intense chemical and biological activity. Primary production in the surface waters is transferred to the benthos, directly or indirectly, by sedimentation. Remineralization of organic matter in the sediments releases nutrients into the overlying waters. These processes are controlled by the physical, chemical, and biological processes in the seawater and the sediments. This project focuses on defining the mechanisms which control these processes so that the impact of man's activities on benthic production and the quality of benthic habitat can be understood and predicted.

2. Long-Term Objectives:

The cage culture of finfish in Atlantic coastal waters has grown rapidly over the past 5 years and urgently requires scientifically based management and regulation tools. The quality of the water and surface sediments near the cage sites is dramatically affected by the dissolved and particulate wastes from the farms. Also, there is potential for the wastes from one farm impacting neighbouring farms or interfering with other more traditional resource users such as well operators and inshore fishermen. This project will provide the necessary information to understand and quantify the flux and fate of wastes from salmon farms.

Specific objectives are to determine the environmental and operational factors that could limit the selection and expansion of sites for salmon cage cultures in the L'Etang Inlet system in New Brunswick. As part of the overall program to develop tools to help manage and regulate this industry, the energy flows associated with salmonid aquaculture are being studied in order to determine the fate of the large quantities of dissolved and particulate wastes associated with the industry. Results from this project will be used to verify a numerical model (Project 718) which in turn will be interfaced with a water quality model to predict cumulative impacts in the L'Etang inlet system in southwestern New Brunswick.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. The field program at the Frye Island, SeaFarm of Canada site will be continued with the emphasis on determining the flux of dissolved and particulate material from the cages and on the fate of nitrogen wastes from the cages. Dye tracer experiments will be conducted at the site in collaboration with G. Bugden (COD, PCS) to determine flushing rates as a function of current. A detailed study of the nitrogen flow in the cages will also be conducted. (Keizer)

The last field work was done in February 1991. Dye tracer experiments were not conducted due to the concern by the Department of Health and Welfare Canada about the lack of information on toxicity to salmon, and potential impact on exposed salmon for human consumption. It was not feasible to conduct the nitrogen flow study in isolation from the flushing experiments.

2. Data and information from the field experiments will be used to verify the SITE model (Project 718). (Keizer)

This is an ongoing exercise. Information from analysis of the field data and from literature surveys has been used to help verify and improve the models developed under Project 718.

3. Salmon farms in the Quoddy Region will be classified on the basis of size (physical and production), water depth and tidal range, current regime, bottom type (sediments and biota), and type of farming operation (management style). (Keizer)

Preliminary investigations revealed that much of this information already existed and was being updated by the New Brunswick Department of Fisheries and Aquaculture. Our requirements have been discussed with their staff and we will have access to the information when it becomes available.

4. If benthic chambers are rebuilt using magnetic couplings to avoid leakage problems, time series measurements of benthic oxygen and ammonia flux at sites under and adjacent to salmon pens in L'Etang Inlet will be made. (Hargrave)

The chambers were not constructed due to a shortage of operating funds.

5. If field trials of the "smart" sediment trap are successful, the equipment will be tested to determine the trajectories of settled particles during a tidal cycle around salmon pens. (Hargrave)

Trap development was delayed due to the PSAC strike. Field trials are now scheduled for February 1992.

#### 4. Additional Accomplishments:

1. Draft manuscripts for both the benthic and pelagic components of the field program have been completed and are undergoing internal review.

#### 5. Goals/Expected Outputs for 1992:

1. Primary publications (two) of the results of the 1989-1991 field work in L'Etang. (Keizer, Hargrave)
2. Conduct a laboratory bioassay of the acute effects of the dye rhodamine B on juvenile and adult Atlantic salmon. This work would be done under contract. (Keizer)
3. If the use of rhodamine B as a tracer proves acceptable, conduct dye tracer experiments at the SeaFarm Canada site in Bliss Harbour, N.B., to determine the flushing rate of dissolved and particulate wastes from the farm cages. (Keizer, Bugden)
4. In conjunction with Goal 3 above, conduct field experiments to measure the nitrogen budget for a salmon cage.
5. Engage a Post-Doctoral Fellow to conduct studies of the microbiological processes affecting the mineralization of particulate wastes from salmon fish farms.

#### 6. Background:

##### Highlights:

The field program was quite successful, but there is still much to be done. Lack of resources, both financial and personnel, severely impacted the project this year. It was expected that the project would be largely supported with AFAP money, which did not materialize. In addition, the Project Leader took a six-week vacation to use up some of his accumulated overtime leave. In order for this project to make further progress, additional resources are needed to contract for various services.

##### Selected Involvements:

##### i. Collaborative Research -

D. Wildish (AIFD, BSB) - seasonal and tidal variations in water chemistry and benthic fluxes at a salmon aquaculture site in Bliss Harbour, N.B.

G. Bugden (COD, PCS) - Currents and water structure at a salmon aquaculture site in Bliss Harbour, N.B.

##### ii. University Liaison -

Dr. D. Scott (Dalhousie University) - Collaboration on a strategic grant investigating the use of microfossil sediment records to infer historical environmental quality at potential aquaculture sites.

##### iii. Communications -

A paper entitled "Modelling the Environmental Impacts of Cultured Salmonids" was presented at the 47th Annual Northeast Fish and Wildlife Conference (May 1991). (Keizer)

A presentation entitled "An Integrated Approach to the Study of Environmental Interactions with the Finfish Cage Culture Industry" was made at an aquaculture workshop (July 25, 1991, Halifax, N.S.).

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Progress was hindered by the lack of funding that was anticipated from the AFAP program. Nevertheless, advances were made preparing data for publication and supporting modelling work under Project 718. Hopefully, funding will be found to carry out the experimental work planned for 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 712

Section:

Project Title: Fish and Habitat Interactions

Project Leader: Messieh, S.N.

Other Researchers:

Work Activity: W.A.1.1.3.1

Key Words: habitat research

1. Project Description:

The importance of fish habitat has long been recognized by DFO and recently affirmed by the issue of a new "Policy for The Management of Fish Habitat." Fish and habitat are interrelated, and the proper management of fishery resources requires the understanding of their interactions. In this project, research is conducted to define the attributes of marine fish habitats in the northwestern Atlantic, and to identify critical habitats of commercially important species. Two general types of marine habitats are investigated: first, fixed habitats such as the spawning locations of Atlantic herring which are fixed features with tangible physical characters; and secondly, transient habitats such as larval and nursery areas which have no fixed boundaries but retain their location by physical oceanographic processes. Research is also conducted on the effects of man-made changes including existing fishing practices on marine fish habitat. Scientific advice of impact on fisheries is given to both fishery resource managers and habitat managers.

2. Long-Term Objectives:

Improve knowledge on fish and habitat interactions. Research results are used to provide scientific advice on the conservation and enhancement of habitat productive capacity for fishery resources, and to mitigate the impact of man-made changes to fish habitat.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue the study on the critical habitat issue, and prepare a publication.

Data on marine habitats in Nova Scotia were collected and analyzed. Inshore and offshore marine habitats were investigated. Inshore habitats comprise estuaries that support nursery areas for many commercially important fish species, aquaculture sites along the Nova Scotia coast, shellfish-harvesting areas, and spawning beds of Atlantic herring. Offshore habitats include fishing banks on the Scotian Shelf and the Canadian sector of Georges Bank. Maps identifying critical habitat areas and potential resource use conflicts were prepared.

2. Investigate the problem of fish offal dumping in the marine environment, examine the potential magnitude of the problem, and recommend alternative actions. Results of this review could stimulate new projects under the sponsorship of the Marine Atlantic Standing Subcommittee on Habitat (MASSH).

Relevant studies on fish waste disposal in Atlantic Canada were reviewed. The review included studies on the characteristics of fish plant wastes and their effects on coastal bays, practices of ocean dumping of fish wastes, and assessment of the impacts of fish offal marine disposal. The study also included recommendations for resolving these problems. A paper was prepared and presented at a MASSH meeting (Dartmouth, N.S., April 1991).

4. Additional Accomplishments:

1. A paper was prepared (jointly with Dr. M. El-Sabb, University of Quebec, Rimouski, P.Q.) for presentation at the International Meeting "Hazards '91" (Perugia, Italy, August 1991). This paper, titled "The Effects of Global Climate Change on Estuarine and Marine Fisheries," discussed the impacts of global warming and sea level rising on marine fisheries and coastal zone ecosystems.

5. Goals/Expected Outputs for 1992:

1. Complete a technical report on the critical marine habitats in the Scotia-Fundy Region.
2. Determine the basic habitat variables (physical, chemical, and biological) that are important for defining the marine habitats in the Atlantic Zone.

Dr. Messieh is retiring at the end of March 1992. The progress and expected outputs of this project depend on the availability of funds required to contract out this work.

## 6. Background:

### Highlights:

#### Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

M.I. El-Sabh (Department of Oceanography, University of Quebec, Rimouski, P.Q.)

iii. Communications -

iv. Contracts Administered -

v. Other -

## 7. Publications:

i. Primary -

Messieh, S.N. 1991. Fluctuations in Atlantic herring populations in the northwestern Atlantic, with particular emphasis on the Gulf of St. Lawrence stocks, p. 155-163. In T. Kawasaki et al. (eds.), Long-term variability of pelagic fish populations and their environment. Pergamon Press (Oxford, U.K.): 402 p.

Messieh, S.N., T.W. Rowell, D.L. Peer, and P.J. Cranford. 1991. The effects of trawling, dredging, and ocean dumping on the eastern Canadian continental shelf seabed. Cont. Shelf Res. 11 (8-10): 1237-1263.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Messieh, S.N. 1991. Fish offal disposal in Atlantic Canada. Discussion paper prepared for the Marine Atlantic Standing Subcommittee on Habitat (MASSH) (Dartmouth, N.S., April 1991): 7 p.

iv. Popular and Miscellaneous -

## 8. Review and Evaluation:

This project is progressing well and fits well with the overall goals of the Habitat Ecology Division. After Dr. Messieh's retirement, it is important to continue on this investigation as part of Project 716. High priority should be given to completing the technical report on critical marine habitats by April 1, 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 713

Section:

Project Title: Bioenergetics of Marine Mammals

Project Leader: Brodie, P.F.

Other Researchers:

Work Activity: W.A.1.1.3.1

Key Words: marine mammals; whales; seals; fisheries interactions; habitat

1. Project Description:

Conduct research on the morphology, physiology, mechanics, feeding, and population energetics of marine mammals in the northern Atlantic, with emphasis on the baleen whales. Knowledge gained from these studies is applied to a variety of scientific and operational problems including zooplankton sampling design, fishing gear design and operation, contaminant (DDT and PCBs) accumulation in seal populations, and habitat alteration.

2. Long-Term Objectives:

Provide improved understanding of the trophic status of marine mammals, on both a local and world scale. Use baleen whales as indicators of marine production and compare these estimates with those obtained using traditional sampling methods. Provide improved understanding of the habitat requirements of marine mammals and the potential impacts of environmental disturbances. Provide scientific advice on management issues concerning marine mammals.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue to analyze past data and prepare publications.

Several manuscripts on marine mammal energetics, biomechanics, and feeding are near completion.

2. Continue collaborative studies on the energetics and feeding of large whales with Icelandic and Norwegian colleagues.

Participated as an invited expert at the Special Meeting on Northern Atlantic Fin Whales (Reykjavik, Iceland) by the Scientific Committee of the International Whaling Commission. The presentation of results of field studies on the physiology, mechanics, and energetics of fin and sei whales were used to demonstrate the physiological and energetic basis for intraspecific body size variation between populations, as well as to demonstrate the thermal, propulsive, and feeding efficiencies which reduce their feeding requirements.

3. In collaboration with other Regions, carry out field programs on marine mammal energetics in Canadian waters.

The closure of the Arctic Biological Station and transfer of its scientists disrupted collaborative studies with the Quebec Region.

4. Maintain a watching brief on the status of harbour porpoise in the Scotia-Fundy Region.

The bycatch of harbour porpoise in groundfish gillnets in the Scotia-Fundy Region has been viewed by the Department as a serious issue, in light of the classification of this species as 'threatened' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Evidence presented by scientists at Guelph University suggested that the population of harbour porpoise was in serious decline through excessive bycatch in gillnets and that density-dependent changes in growth of individuals was considered as further evidence. The ramifications for the Canadian Atlantic gillnet fishery are serious; and, as well, amendments to the United States Marine Mammal Protection Act provide for unilateral trade embargoes against countries in violation of United States legislation on protection of marine mammals. Dr. Brodie was requested to assess the available information on the species. His findings were presented to the Harbour Porpoise Recovery Review Committee at the July and November meetings providing another interpretation: The population estimate would be found to be an underestimate, and that density-dependent growth changes and population redistribution were factors which were coupled with the abundance and distribution of herring. The preliminary results of an extensive survey conducted by United States scientists tend to confirm this, indicating as much as a tenfold underestimate in the population, much of this attributed to redistribution; and there was agreement at the November meeting that the alternative explanation of the density-dependent factors, as proposed by Dr. Brodie, is a more realistic interpretation. This presentation was well received by the several fishermen's unions and organizations represented who foresaw financial hardship if the crisis was not resolved. As well, the alternative explanation was well received by the Canadian and American scientists who had proposed the original hypothesis of declining stocks.

5. Provide assistance to DFO Operations in handling marine mammal strandings and other "emergencies."

As of this year, the responsibility has been assumed by DFO Operations, and one or more foreign-based and recently formed local stranding groups. Marine mammal strandings are so often a media event with the usual unscientific assessment by various non-government agencies; therefore, Dr. Brodie is reluctant to continue involvement unless he is in complete control of the operation.

#### 4. Additional Accomplishments:

1. Subpoenaed to appear as an expert witness in the Provincial Court of Nova Scotia (July 22, 1991), on behalf of DFO. Charges had been laid concerning harassment of cetaceans under the Fisheries Act (Section 79(1) 1985 c F-14). This was, apparently, the first time DFO had taken such action, and the 30- to 40-minute scientific testimony on animal behaviour and energetics as applied to migrating cetaceans, which was well received by the DFO legal counsel and presiding judge, will be used as a basis for future actions by the Department. This contribution to Department activities is yet another example of the breadth of application of long-term fundamental research to the day-to-day problems which arise.
2. Invited to be a member of the Advisory Board of the Canadian Journal of Zoology for a three-year term commencing January 1992.

#### 5. Goals/Expected Outputs for 1992:

1. Continue studies of rorqual feeding mechanics.
2. Continue studies of seal and walrus energetics and mechanics.
3. Continue to monitor harbour porpoise/fisheries in the Bay of Fundy/Gulf of Maine (proposed a joint paper with Guelph University colleagues to reassess the problem).
4. Continue to have input on the Great Whale Hydroelectric Development Program and marine mammal habitat.

#### 6. Background:

Highlights:

Selected Involvements:

##### i. Collaborative Research -

Continue collaboration with Icelandic and Norwegian colleagues on rorquals and pinnipeds.

##### ii. University Liaison -

Lecturer on physiology, mechanics, and energetics of marine mammals - Department of Biology, Dalhousie University (Course 4060/5723).

Invited to Norway by the Norwegian Research Establishment (SINTEF) to present a seminar on marine mammal energetics at the University of Trondheim (February 1991). This was sponsored by the SINTEF Biomedical Section on Human Physiology in Extreme Environments.

##### iii. Communications -

Extensive interview by MITV concerning marine mammals: How they are perceived by scientists, the public, and the media, in terms of their life-history, behaviour, and their role in ecosystems. This will form part of a half-hour television special on whales.

Lecture to Halifax Field Naturalists on marine mammals and fisheries oceanography.

Invited participant in the University Rationalization Workshop - School of Architecture, Technical University of Nova Scotia.

##### iv. Contracts Administered -

Advised Fisheries and Habitat Management Branch on a contract concerning the depth of dive studies on harbour porpoise.

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

## iii. Scientific and Technical -

Brodie, P.F. 1992. Summary of research conducted on Rorquals from the Icelandic catch. Scientific Reports of the International Whaling Commission: Special Meeting on the Northern Atlantic Fin Whale: in press.

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

Considerable effort has been given to advising on harbour porpoise in the Bay of Fundy and collaborative work with Scandinavians has continued. In light of the upcoming impact assessment of the Great Whale Project, increased involvement is anticipated.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 715

Section:

Project Title: Size-Dependent, Bioenergetic Processes in Fish Habitat

Project Leader: Kerr, S.R.

Other Researchers: Silvert, W.L.; Boudreau, P.R.

Work Activity: WAA11113.1

Key Words: modelling; habitat research; bioenergetics; heritability; ballast water; ecosystem integrity

1. Project Description:

Evaluation of the effects of environmental factors and habitat change on fish habitat productivity.

2. Long-Term Objectives:

Develop procedures for evaluating and predicting the interaction of habitat variables with the production capacities of fish stocks and communities.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Carry out medium-term research on alternative procedures for fish production forecasting and analysis, in relation to habitat variables. This will entail continued development of a major five-year research program in cooperation with the various participants in the OPEN network, occupying a major portion of Dr. Kerr's time. (Kerr)

After the usual teething difficulties, this program is now up and running smoothly. The 'Bioenergetics and Heritability' component that Dr. Kerr co-supervises (with R.G. Boutilier) has grown to include 12 personnel; most equipment has been purchased, laboratory facilities are essentially complete, and brood stocks are established and producing eggs. A number of experimental and analytical investigations are currently producing results.

2. Continue collaborative studies of size-dependent production processes. A further primary publication on the subject is in preparation for submission in 1991. (Boudreau, Dickie, Kerr)

The planned publication was recently published. It provides a synthetic overview of the relation of both production per unit biomass and biomass per unit area to the biomass distributions of individual organism sizes within aquatic production systems.

3. Comparative analysis of the size-structures of research trawl survey data for the Scotian Shelf. Supported by an NSERC operating grant, this graduate student research will probably be completed in thesis form in 1991, with journal publication to follow at a later date. (De Aracama, Kerr)

This innovative work has produced three intriguing results. First, the observations by Pope and colleagues, that orderly size distributions obtain on a Scotian Shelf-wide basis for the relatively narrow size-window of the trawlable demersal fishes, has been confirmed for the Scotian Shelf. Secondly, for the first time it has been shown that characteristic size distributions persist at the smaller scales of individual statistical regions within the Shelf fishery; and thirdly, that characteristic size-distribution patterns are consistent with species assemblage patterns published earlier in the literature, on the basis of independent multivariate statistical techniques. This thesis is now in first draft, with completion and defence intended in the early part of 1992.

4. Continued involvement with the ballast-water problem is planned, including the organisation of a DFO workshop on the question in the spring of 1991, at the request of CAFSAC. (Kerr)

The planned workshop was held on schedule, and was quite successful within the constraints of travel limitations. A summary of the workshop proceedings is in first draft form, and will be available early in 1992, other demands on Dr. Kerr's time (see above) permitting.

5. Continue working with the DOE/USEPA subcommittee on ecological criteria for assessing the health of the Lake Ontario ecosystem. It seems likely this work will conclude with a report to be submitted in 1991. (Kerr)

Jurisdictional delays between the sponsoring agencies seem to underlie an appreciable lag in the completion of this task; however, after a period of some months, the next workshop is scheduled for the middle part of January 1992. The possibility that meaningful results may accrue suggests that continued participation is worth the effort.

6. Participate in the DFO workshop on size-dependent processes in the northern cod fisheries, to be organized by the Northwest Atlantic Fisheries Centre (St. John's, Nfld). (Silvert, Kerr)

The participation identified was realized in the form of presentations contributed by Silvert, Boudreau, and Kerr. The workshop proceedings, when available, should prove to be of considerable interest. In the interim, this project is considered complete.

#### 4. Additional Accomplishments:

1. Concluded duties with the DFO Scotia-Fundy Library Committee, which has submitted its final report and is now disbanded. (Kerr)

#### 5. Goals/Expected Outputs for 1992:

1. Carry out medium-term research on alternative procedures for fish production forecasting and analysis, in relation to habitat variables. This will entail continued development of a major 5-year research program in cooperation with the various participants in the OPEN network, occupying a major portion of Dr. Kerr's time. (Kerr)
2. Continue collaborative studies of size-dependent production processes. (Boudreau, Dickie, Kerr)
3. Comparative analysis of the size-structures of research trawl survey data for the Scotian Shelf. Supported by a NSERC Operating Grant, the spatial distribution phase of this work is nearly complete with a MSc thesis now in first draft. A second student has recently joined Dr. Kerr to carry on with the temporal distribution phase. (De Aracama, Duplisea, Kerr)
4. Continue working with the DOE/USEPA subcommittee on ecological criteria for assessing the health of the Lake Ontario ecosystem. (Kerr)

#### 6. Background:

##### Highlights:

The OPEN project which Dr. Kerr co-supervises is showing remarkable success in its interdisciplinary focus on cod bioenergetics and heritability. Forty genetic probes have been developed, performance analysis of larvae and adults is well underway, macrocosm evaluation of cod behavioural and physiological response to habitat variables has yielded innovative results, and field observations of young-of-year growth and recruitment have been successful.

##### Selected Involvements:

##### i. Collaborative Research -

Extensive collaboration is involved with the researchers from the seven universities and two DFO laboratories, together with other individuals involved in the OPEN research network. Additional collaborations will occur with L. Dickie and S. Smith (MFD), and R. Ryder (OMNR).

##### ii. University Liaison -

Research Associate in the Departments of Biology and Oceanography, Dalhousie University - currently supervise three graduate students working on habitat-related topics and serve on the research advisory committees of three others. One graduate student completed a M.Sc. on cod behaviour and physiology in 1991. Two graduate students presented results of their work at the Canadian Conference for Fisheries Research in 1991. Dr. Kerr lectured in the undergraduate Fish Biology course, and taught a graduate module in Fisheries Bioenergetics. Dr. Kerr continues to serve on the Dalhousie Aquatron Advisory Committee.

##### iii. Communications -

Invited presentation on fisheries recruitment to annual meeting of Canadian Meteorological and Oceanographic Society.

Three invited presentations to the Northern Cod Workshop (St. John's, Nfld.). (Silvert, Boudreau, Kerr)

Local seminar on OPEN at BIO (Dartmouth, N.S.)

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

Boudreau, P.R., L.M. Dickie, and S.R. Kerr. 1991. Body-size spectra of production and biomass as system-level indicators of ecological dynamics. *J. Theor. Biol.* 152: 329-339.

Thiebaut, M.L., P.R. Boudreau, and L.M. Dickie. 1991. An analytical model of acoustic fish reflection for estimation of maximum dorsal aspect target strength. Can. J. Fish. Aquat. Sci. 48: 1772-1782.

ii. Interpretive Scientific -

iii. Scientific and Technical -

Rice, J., and S.R. Kerr. 1991. Fish working group report. Global Oceans Ecosystems Dynamics. Report 2: 65-70.

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project is hitting full stride and benefits from excellent university collaboration.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 716

Section:

Project Title: Habitat of Geographic Information Systems (GIS)

Project Leader: Boudreau, P.R.

Other Researchers: Keizer, P.D.; Silvert, W.L.

Work Activity: W.A.1.1.3.1

Key Words: GIS; habitat sensitivity mapping

1. Project Description:

To explore and develop the application of a Geographic Information System (GIS) for evaluating the productive capacity of freshwater, estuarine, and marine habitats, for monitoring changes in these habitats as a result of man's activity, and for making scientific data readily available to environmental managers.

2. Long-Term Objectives:

To establish methods and the capability of using GIS for data entry, storage, manipulation, and information dissemination on environmental variables affecting the productive capacity of freshwater, estuarine, and marine habitats. The resulting data bases and accompanying software will be used in support of habitat science research projects, to improve information exchange among DFO science Divisions, and to improve the provision of science advice to habitat managers. GIS systems must be developed under careful regional coordination, and this project will complement efforts in other Divisions and Departments.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. To continue the exploration and development of GIS methods for use in maintaining and providing access to general data bases compiled by the Division on habitat variables. An attempt will be made to use a GIS for handling a portion of the phytotoxin database. (Boudreau)

The phytotoxin database has been imported into the INFOCUS/QUIKMAP mapping system.

2. Attempts will be made to incorporate GIS methods in the description and modelling of habitat variables which affect production. (Boudreau)

No work was done on this objective.

3. Implement the FMG GIS system within the Division and explore its application to existing research projects. (Boudreau, Keizer, Silvert)

A working group on GIS was convened to discuss available GIS systems for use within the Habitat Ecology Division. As a result of this and other discussions, the INFOCUS/QUIKMAP system was chosen for developing a georeference database for the Habitat Ecology Division.

4. Additional Accomplishments:

1. Application has been made under the Green Plan for habitat sensitivity mapping. Funds have been approved and a contract has been let to begin work on this project. (Boudreau, Keizer, Gordon)

5. Goals/Expected Outputs for 1992:

1. To be Scientific Authority for the Habitat Sensitivity Mapping contract.
2. To set up the hardware and software system to run the INFOCUS/QUIKMAP mapping system for use in managing Divisional databases on habitat parameters.

6. Background:

Highlights:

Awarding of Green Plan funding at the end of 1991.

**Selected Involvements:**

## i. Collaborative Research -

Interacted with R. Rutherford (Habitat Management Branch) in evaluating GIS systems for joint development.

## ii. University Liaison -

## iii. Communications -

Organized a GIS/database management workshop for DFO and DOE in April 1991.

## iv. Contracts Administered -

## v. Other -

**7. Publications:**

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

## iv. Popular and Miscellaneous -

**8. Review and Evaluation:**

Progress was limited for most of 1991 because of other demands on Mr. Boudreau's time. However, this project is about to take off now that Green Plan funds have been acquired. Considerable progress is anticipated for 1992. For January to March (at least), Mr. Boudreau will be able to give full attention to habitat mapping while on assignment with Canadian Hydrographic Service.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 718

Section:

Project Title: Evaluation of Estuarine and Continental Shelf Habitats

Project Leader: Silvert, W.L.

Other Researchers: Durvasula, S.R.; Gordon, D.C.; Hargrave, B.T.; Keizer, P.D.; Messieh, S.N.

Work Activity: W.A.1.1.3.1

Key Words: ecological modelling; habitat evaluation

1. Project Description:

Using ecological modelling tools, and other appropriate methods, integrate available physical, chemical, and biological data to improve general understanding of the structure, distribution, and dynamics of estuarine and continental shelf habitats which support valuable fishery resources. Apply knowledge gained to the assessment of marine habitat issues, including environmental impact assessment.

2. Long-Term Objectives:

Maintain, and if possible increase, the current productive capacity of important estuarine and continental shelf habitats off eastern Canada through knowledge of factors controlling the productive capacity, by assessing the relative importance of specific habitats and assessing the effects of anthropogenic chemical, physical, and biological changes on habitat and the fishery resources they support.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Continue to develop, in collaboration with other divisions and with input from habitat managers, an ecological model for the L'Etang Inlet which can be used to evaluate the carrying capacity for salmon cage aquaculture. (Silvert, Keizer, Gordon)

This work has continued throughout the year. Several different model formulations have been developed, and a series of meetings and workshops has been held to evaluate them. The current phase of model development is expected to culminate with presentation of how these results can be integrated with a water-quality model being developed by Physical and Chemical Sciences Branch (PCS), which is currently scheduled for January 1992 in St. Andrews, N.B. Progress to date is fully satisfactory.

2. Continue development of models of shellfish toxicity which can be used to plan research and monitoring programs. (Silvert, Durvasula)

A model of the dynamics of domoic acid in Cardigan Bay, P.E.I., has been completed and submitted for publication. Extensions of this modelling approach are currently being explored with the National Research Council and several foreign colleagues. Progress to date is fully satisfactory.

3. Continue development and maintenance of the BSIM modelling package, ensuring that the package is a viable tool for microcomputer as well as mainframe use. This requires development of distribution quality versions for the Macintosh, Atari ST, and MS-DOS as well as additional documentation and creation of a context-sensitive help facility available from with BSIM. (Silvert)

The BSIM package has been further refined and enhanced, particularly with respect to the graphics output options. The PC graphics have also been rewritten and improved. However, support for the Macintosh and Atari ST versions has been reduced because of limited demand for this kind of simulation software and the unavailability of adequate development tools for these computer platforms. The central development system for BSIM was shifted from the Wicat 160 to a Silicon Graphics 4D/25 computer; and although most of the translation of the code was completed early in the year, the transition involves major changes to the documentation, and this is only partially complete. Part of the plotting package development was contracted out, but the contract was cancelled because of limited funding. It may be necessary to rely on external contractors to continue with this plotting work, update the Macintosh and Atari ports, and complete the documentation changes. Progress to date is satisfactory.

4. Continue development of the generic model of continental shelf habitats with particular emphasis on benthic submodels and dynamic stability of these systems. (Silvert)

A paper on this subject was presented at a benthic modelling workshop in The Netherlands and has been published in the proceedings of the workshop. Additional research in this area has had to be postponed because of time limitations. Progress to date is satisfactory.

5. Install and configure new divisional computer system for improved modelling capability, and implement networking and data transfer capabilities to support the modelling program. (Silvert, Keizer)

A Silicon Graphics 4D/25 Personal Iris was purchased in February and has been installed and set up for use both as a divisional central computer and as a workstation for ecological modelling work. All aspects of this work were satisfactorily completed early in the year, with the exception of networking support which has proven very difficult because of problems arising from deficiencies in the BIO Ethernet connections to the Fish Lab.

6. Investigate physical factors affecting estuarine habitat, and establish liaison with PCS concerning estuarine classification and interfaces between physical and biological models. (Messieh, Silvert)

The main thrust in this area has been maintaining liaison with the estuarine modelling programs in PCS, primarily the ASA model of the L'Etang Estuary. All requested information on biological sources due to aquaculture has been provided to PCS as needed. Contact with the estuarine classification program has been maintained, but the Habitat Ecology Division's role in this work is mostly reactive at the present time.

7. Review Grand Banks ecosystem model and update it in order to test its possible utility in understanding the ecological environment of northern cod. (Silvert)

This work was satisfactorily completed and presented at a DFO workshop on northern cod in St. John's, Nfld.

#### 4. Additional Accomplishments:

1. An invited paper on modelling the effects of environmental change on fish larvae was presented at the ICES 79<sup>th</sup> Statutory Meeting. A prototype decision support system for evaluating aquaculture permit applications was developed and demonstrated at several meetings. (Silvert)
2. The following software were developed: (Silvert)
  - Prototype Decision Support System for Aquaculture. Two versions were developed: 1) The original version uses an expert system shell, VP-EXPERT, and can only be used under terms of the software license; and 2) To meet requests for a demonstration version of the program that could be freely distributed, a look-alike version of the original expert system was programmed in QuickBASIC and has been distributed both as source code and as an executable file.
  - FLINK, a Fortran link mapping tool. This tool is widely used by Fortran programmers and is distributed as both source for Unix systems and as an executable file for MS-DOS systems.
  - FXRREF, a Fortran cross referencer. This is another tool widely used by Fortran programmers to keep track of all the variables in large sets of programs. Currently it is available only for Unix systems.
  - FDEP, a Makefile dependency generator for Fortran program development. This tool is used by Fortran programmers who rely on the Unix make utility for managing program compilation. Currently it is available only for Unix systems.
  - The BSIM package is also widely distributed, and some of the components of the BSIM package (such as the parser) have been distributed independently. These programs have been distributed by floppy disk, electronic mail, and ftp file transfer. FXREF and FLINK have also been distributed via UseNet news.
3. Prepared a discussion paper on the role of numerical modelling in designing monitoring studies and conducting environmental assessments for an ICES working group. (Gordon)

#### 5. Goals/Expected Outputs for 1992:

1. Continue to develop, in collaboration with other divisions and with input from habitat managers, an ecological model for the L'Etang Inlet which can be used to evaluate the carrying capacity for salmon cage aquaculture. (Gordon, Hargrave, Silvert, Keizer)
2. Continue development of models of shellfish toxicity which can be used to plan research and monitoring programs. (Silvert, Durvasula)
3. Continue development and maintenance of the BSIM modelling package. (Silvert)
4. Continue development of the generic model of continental shelf habitats with particular emphasis on benthic submodels and dynamic stability of these systems. (Silvert)
5. Maintain a divisional computer system, particularly with respect to support for the modelling program. (Silvert, Keizer)
6. Investigate physical factors affecting estuarine habitat, and establish liaison with PCS concerning estuarine classification and interfaces between physical and biological models. (Silvert, Messieh)
7. Resume earlier objective of developing models for studying the effects of habitat changes on early life stages of fish. (Silvert)

#### 6. Background:

Highlights:

## Selected Involvements:

## i. Collaborative Research -

Biological Station, St. Andrews, N.B. (Silvert, Gordon, Keizer)  
 Instituto Nacional de Investigação das Pescas, Lisbon. (Silvert)  
 Ira Darling Center, University of Maine, Walpole, Maine. (Silvert, Gordon, Keizer)

## ii. University Liaison -

## iii. Communications -

Several presentations on the L'Etang modelling program, including posters and seminars.

## iv. Contracts Administered -

Department of Mathematics, Statistics and Computer Science, Dalhousie University: Computer communications and networking - \$0.5 K. (Silvert)

KJM Computer Graphics: Software development - \$1.0 K. (Silvert)

ESSA: Atlantic Salmon Acidification Model (Silvert as member of review committee).

## v. Other -

7. Publications:

## i. Primary -

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

Silvert, W.L. 1991. Experiments in benthic modelling, p. 175-188. In: P.M.J. Herman and C.H.R. Heip (eds.). Report of the Workshop, Modelling the Benthos (March 20-22, 1991, Yerseke, The Netherlands). Delta Inst. for Hydrobiol. Res., Royal Netherlands Academy of Arts and Sciences, Comm. 538.

## iv. Popular and Miscellaneous -

Keizer, P.D., W.L. Silvert, B.T. Hargrave, and D.C. Gordon, Jr. 1991. Modelling the environmental impacts of cultured salmonids. Paper presented at the Northeast Fish and Wildlife Conf. (May 1991, Augusta, Maine).

Silvert, W.L. 1991. The BSIM cookbook. BSIM-Central. Internal DFO Rep.: 23 p.

Silvert, W.L. 1991. BSIM cookbook supplement for MS-DOS. Internal DFO Rep.: 12 p.

Silvert, W.L. 1991. BSIM cookbook supplement for Unix. Internal DFO Rep.: 5 p.

Silvert, W.L. 1991. BSIM programmers' manual. Internal DFO Rep.: 20 p.

8. Review and Evaluation:

This project continues to provide a healthy balance of applied and basic research on numerical modelling. It responds well to the needs of DFO. A novel workshop with environmental managers and industry is planned for January 1992.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 719

Section:

Project Title: Contaminant Fluxes in Marine Benthic Food Webs

Project Leader: Hargrave, B.T.

Other Researchers: Peer, D.L.; Phillips, G.A.

Work Activity: W.A.1.1.3.2

Key Words: contaminants; benthic habitat research

1. Project Description:

Consider the impact of chemical contaminants, physical disturbance, and temperature changes on marine benthic systems.

2. Long-Term Objectives:

Develop monitoring techniques which quantify the impact of chemical contaminants, physical disturbance, and temperature changes on benthic species community structure and community functional processes such as nutrient fluxes and metabolic activities.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Summary of data for benthic macrofauna biomass distribution, sediment organic matter, and contaminants (trace metals, PAHs) in surface sediments of Halifax Inlet for presentation at the 2nd Halifax Inlet Workshop (February 1991, Halifax, N.S). (Peer, Hargrave, Tay)

Co-investigators in this project completed analyses of surface sediment from six stations in Halifax Inlet for trace metals, PAHs, PCBs, organic carbon and nitrogen, macrofauna biomass, and species diversity. Rank correlations were calculated and results presented at the 2<sup>nd</sup> Halifax Inlet Workshop (February 1991, Halifax, N.S.).

2. Continued monthly sampling of faunal colonization traps in collaboration with C. Schafer (AGC, DEMR). (Hargrave)

Dr. Hargrave (with assistance of D. Duplisea, a summer student) continued collaborative work with C. Schafer (AGC, DEMR) to monitor biomass of fauna colonizing sterile sediment exposed in Bedford Basin. A temperature increment of +4°C above ambient was maintained by an electrical resistance heating in one set of sample trays. Comparisons will be made of meiofauna and macrofauna biomass in replicate samples taken at monthly to bimonthly intervals to quantify the effect of temperature on colonization rates and species composition.

3. Participation in a Sloan Foundation-sponsored workshop at WHOI (January 7-10, 1991) to plan a research program of investigations to assess the ocean option of future waste management. (Hargrave)

Dr. Hargrave participated in the workshop at WHOI to discuss research needs for monitoring impacts of disposal of incinerated solid wastes in deep-sea sediments. He presented an overview of benthic biological processes that could mobilize waste material disposed on the seabed and he contributed to a WHOI research planning document (see Section 6iii).

4. Participate in a Rockefeller Foundation workshop (March 11-15, 1991, Bellagio, Italy) to discuss predictive capabilities of techniques in marine ecotoxicology. (Hargrave)

Dr. Hargrave was invited to attend a 5-day workshop in Bellagio, Italy, to discuss utilization of integrated marine benthic systems to monitor and predict ecotoxicological changes due to man's activities. He contributed a manuscript that will be published in the proceedings of the workshop as an IOC Special Publication.

5. The new data for benthic macrofauna biomass distribution, collected in 1990, will be compared with an earlier survey (1970) using similar sampling methods. The comparison may indicate if long-term changes in benthic fauna biomass have occurred. (Peer)

Some progress was made in comparing benthic macrofauna biomass in samples collected in 1970 and 1990 in Halifax Inlet, but planned work was not completed due to Mr. Peer's early retirement. Species lists and biomass distributions were prepared, but no statistical analyses were performed. The small number of stations and the fact that samples were not obtained from precisely the same locations in the 2 years mean that direct comparison of data is not possible. Results from sampling carried out by contractors for the Halifax Harbour Cleanup Corporation during 1991 provide new data that should be combined with previous observations before further analyses are attempted.

#### 4. Additional Accomplishments:

1. One co-authored primary paper (see Section 7i) was published during the year. A manuscript on stable element distribution in deep-sea amphipods arose from field work conducted between 1983 and 1987 was accepted for publication and will appear in 1992. Collaboration with French scientists under the Canada-France Science Exchange Agreement made elemental analyses by neutron activation possible using facilities at CEN-Saclay, France. The paper on benthic oxygen consumption is a synthesis of data from studies on the Scotian Shelf, Gulf of St. Lawrence, Grand Banks, and Labrador Shelf. It arose as a result of collaboration with faculty and students at Dalhousie University (Department of Oceanography).
2. Two book chapters (See Section 7ii) prepared during 1990 as a contribution to Fundamentals of Aquatic Ecology (R.S.K. Barnes and K.H. Mann, eds.) were published in 1991. The chapters on ecological processes in deep water and effects of man's activities on aquatic systems review various structural and functional properties of aquatic benthic systems that have been used to assess impacts of natural and man-induced environmental changes.
3. A proposal to use benthic chambers to measure sediment-water fluxes of contaminants was prepared for the Green Plan Toxic Chemicals Program in collaboration with P. Yeats (MCD, PCS) and R. Cranston (AGC, DEMR). Funding will be used to construct new chambers of non-metallic material, for summer student support, and to cover costs of trace metal and organic analyses.
4. Dr. Hargrave's involvement in OPEN (NSERC Centre of Excellence) as a co-investigator with J. Grant (Dalhousie University, Department of Oceanography) continued during the year. Their module of the project (Adult Scallop Trophic Resources) supports one research assistant, a post-doctoral fellow, three graduate students, and two biologists. Construction of a new current meter-controlled particle trap (Smartrap), under the direction of G. Siddall (Systems Engineering Group, BIO Institute Facilities), fell behind schedule due to the PSAC strike and delays in parts delivery. Field trials planned for late 1991 will be carried out in the spring of 1992. Five 24-hour experiments to evaluate changes that might be expected in particle flux if samples are collected at hourly intervals over one tidal cycle were carried out in Nova Scotia (Lunenburg Harbour and Upper South Cove) and Newfoundland (Broad Cove, Terra Nova National Park) at sites being used to investigate the feasibility of scallop aquaculture. Preliminary results were presented at the OPEN annual meeting (November 15-17, 1991) and summarized in the OPEN Newsletter (see Section 7iv).

#### 5. Goals/Expected Outputs for 1992:

1. Completion of benthic fauna colonization studies with C. Schafer (AGC, DEMR). Data will be compiled and results for effects of temperature on colonization and growth of different-sized organisms assessed. (Hargrave, Schafer)
2. Participate in a multi-disciplinary study of particle fluxes during the Spring Bloom in Bedford Basin. Settled material will be analyzed for grain size, organic carbon, nitrogen, plant pigments, trace metals, and  $^{234}\text{Th}$ . (Hargrave, Nivan, Yeats, Buckley, Kranck, others)
3. If Green Plan funds are available, a summer student will carry out field and laboratory studies to monitor sediment-water fluxes of trace metals. (Hargrave, Yeats, Cranston)

#### 6. Background:

##### Highlights:

The general focus of this project continues to be the development of various monitoring techniques to assess changes in sediments and benthic communities arising from man's activities. A primary study site for field work is Halifax Inlet due to its proximity to BIO and the gradients of contaminants in sediments in Halifax Harbour. Advice was provided through meetings of the Science Advisory Committee on Halifax Harbour and to consultants with J. Whitford Ltd., who undertook detailed site investigations as part of developing an Environmental Impact Statement for siting of a regional sewage-treatment plant. Mr. Peer's retirement in June 1991 prevented a complete assessment of benthic macrofauna biomass data as was planned. Future detailed analyses of benthic community species composition will have to be carried out under contract as no staff are available within DFO to undertake this work.

##### Selected Involvements:

##### i. Collaborative Research -

Co-investigator with J. Grant (Department of Oceanography, Dalhousie University) in NSERC Centre of Excellence (OPEN) (1991-1995) (Adult Scallop Trophic Resources)

##### ii. University Liaison -

Dr. Hargrave served as a Departmental Scientific Liaison Advisor for two DFO Science Subvention grants during the year. Dr. P. Wangersky (Dalhousie University, Department of Oceanography) with his student Mr. W. Chen are evaluating a high-temperature combustion method for determination of dissolved organic carbon and nitrogen in seawater. Dr. R. Marinelli, a PDF with Dr. B. Boudreau (Dalhousie University, Department of Oceanography) arrived at Dalhousie University in September. She will investigate irrigation of porewaters in coastal and harbour sediments through experiments and modelling studies.

##### iii. Communications -

Research activities in Halifax Harbour were reviewed at a public lecture (BIO summer visitor's program) and during a school visit (Queen Elizabeth High School Career Day) during the year.

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

Grant, J., C.W. Emerson, B.T. Hargrave, and J.L. Shortle. 1991. Benthic oxygen consumption on continental shelves off eastern Canada. Cont. Shelf Res. 11: 1083-1097.

ii. Interpretive Scientific -

Hargrave, B.T. 1991. Ecology of deep-water zones, p. 77-90. In: R.S.K. Barnes and K.H. Mann (eds.), Fundamentals of aquatic ecology. Blackwell Scientific Publ. (Oxford).

Hargrave, B.T. 1991. Impacts of Man's activities on aquatic systems, p. 245-264. In: R.S.K. Barnes and K.H. Mann (eds.), Fundamentals of aquatic ecology. Blackwell Scientific Publ. (Oxford).

iii. Scientific and Technical -

Fisher, N., B.T. Hargrave, S. Fowler, S. Louma, J. McDowell-Capuzzo, T. O'Connor, and J. Stegeman. 1991. Bioavailability of Chemicals, p. 23-32. In: D.W. Spencer (ed.), An abyssal ocean option for waste management. Woods Hole Oceanogr. Inst. Rep. 1991.

iv. Popular and Miscellaneous -

Emerson, C., J. Grant, and B.T. Hargrave. 1991. Oceanographic processes and scallop trophic resources, p. 7. In: Channels, Vol. 1, June 1991.

8. Review and Evaluation:

This productive project is on track and benefits from collaboration with many scientists. Results are applied to local habitat issues most effectively.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 720

Section:

Project Title: Organochlorines in Arctic Ocean Marine Food Webs

Project Leader: Hargrave, B.T.

Other Researchers: Phillips, G.A.; Vass, W.P.; Harding, G.C.; Conover, R.J.; Welch, H.E.

Work Activity: W.A.1.1.3.2

Key Words: contaminants; habitat research; Arctic Ocean

1. Project Description:

Quantify the long-range atmospheric and marine transport of organic contaminants and their incorporation into food webs in the Arctic Ocean.

2. Long-Term Objectives:

Provide baseline measurements of major semi-volatile organics (chlorinated pesticides, PCBs) in the Canadian high Arctic Ocean environment by sampling snow, seawater (dissolved and particulate phases), plankton, benthos, fish, and sediments. Assess the relative importance of atmospheric versus oceanic input of these contaminants to the Arctic Ocean by seasonal measurements. Evaluate the bioconcentration of these compounds for comparison with data from more southern latitude ocean sites to assess input of organochlorines to food webs utilized as food by native populations.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Processing of Ice Island sediment trap samples for microscopic and chemical analyses will be carried out between November 1990 and March 1991. The work is described as a project under the Canada-Germany Research Exchange Agreement with collaboration of B. von Bodungen (Kiel University, Germany). An invitation to visit Kiel (March 15 to April 15, 1990) has been extended where data analyses and sample work-up will be completed. A draft manuscript will be prepared for primary publication. (Hargrave)

A visit to Kiel University was completed as planned under the auspices of the Canada-Germany Science and Technology Exchange Agreement. All analyses of samples from the two multi-cup traps suspended under the Ice Island from September 5, 1989, to September 3, 1990, were completed. A co-authored manuscript (Hargrave, Bodungen, Stoffyn-Egli, and Mudie) was submitted for review.

2. Determinations of organochlorines in Arctic marine biota collected from the Ice Island are largely completed. Outstanding data (organochlorines in snow, surface melt water in lakes that form briefly on the Ice Island in July to August) has not been summarized for publication. No additional field work from the Ice Island is planned. The unpublished data will be reported either in a technical report, or a primary publication. (Phillips and Hargrave)

Data for organochlorine concentrations in biota collected from the Ice Island between 1986 and 1990 were summarized in a manuscript (co-authored with Dr. G.C. Harding), which was submitted and accepted for publication (Arch. Environ. Contam. Toxicol.). A draft of the data report on intercomparisons of organochlorine concentrations measured in replicate samples by four different laboratories was completed and will be published in 1992.

3. Involvement of B.T. Hargrave as a co-investigator in a NSERC Strategies Grant on "Fluxes of Organobromines Between the Atmosphere and the Ocean" with Dr. R. Moore will continue in 1991. Methods to measure organobromines in seawater have been developed by a Ph.D. student in Chemical Oceanography at Dalhousie University, and these will be applied to measurements of these compounds in sediment pore water.

Dr. Hargrave's collaboration with Dr. R. Moore on his NSERC Strategic Grant has continued. The project supports one P.D. and three graduate students. Advice has been provided on the role of epontic algae and benthic fauna in mediating transfers and transformations of organohalogenes at the ice-water and sediment-water interfaces. No collaborative field work has been completed to date, but this may be possible during work planned for an over-wintering experiment described in Section 5 below.

4. A manuscript on organochlorine compounds present in the marine food web of the southern Gulf of St. Lawrence will be prepared if LRTAP funding is approved. (Harding)

No LRTAP funding was available for this work in 1991. Data for organochlorine concentrations in seawater and various size classes of zooplankton are tabulated and will be analyzed for trends over time when time permits.

5. A new field study in St. Georges Bay to determine the rate at which organochlorines enter the marine food web from the atmosphere will be carried out. Air, rainwater, seawater, suspended particles, plankton size categories, and fish compartments will be measured. (Harding, Addison, Hargrave, Vass, Zinck)

This work was not undertaken in 1991 due to the lack of LRTAP funds. Further sampling to continue this work will depend on funding under the Green Plan Toxic Chemicals Program. A proposal was submitted to provide funding support this project.

#### 4. Additional Accomplishments:

1. Two primary papers that review the distribution of organochlorine contaminants in Canadian Arctic atmospheric, terrestrial, freshwater, and marine environments (co-authored with L. Barrie, D. Muir, and others) were accepted for publication in Science of the Total Environment to appear in 1992.
2. A proposal to continue this project in an Arctic region of higher productivity than was studied from the Ice Island was submitted to the Interdepartmental Technical Committee on Arctic Contaminants. The proposal for a 5-year project to measure the incorporation of organochlorines in the marine food web near Resolute Bay was accepted. Treasury Board approval of funding of the Arctic Environment Strategy will provide support for the work from 1991 to 1996. Funds made available in FY 1991/92 were used to complete an inter-laboratory comparison of organochlorines measured in biota collected from the Ice Island in 1987 and 1988. A 2-day planning meeting was held in Winnipeg (November 28-29, 1991) to discuss logistics for a 12-month over-wintering study to begin in September 1992. Collaboration with Drs. H. Welch (DPO Winnipeg) and R.J. Conover (BOD, BSB) will allow the study of organochlorines in the marine food web to be coordinated with studies of food-web trophodynamics.

#### 5. Goals/Expected Outputs for 1992:

1. Initiate a 12-month over-wintering sampling program for organochlorines at Resolute Bay, Northwest Territories. The project will begin with the first trip (September 5-15, 1991) during the open water period, and continue with monthly sampling of snow, seawater, planktonic, and benthic crustaceans, and fish at monthly intervals until August 1993. (Hargrave, Phillips)
2. Publish a primary paper summarizing results from the 12-month deployment of sediment traps under the Ice Island. (Hargrave, Bodungen, Stoffyn-Egli, Mudie)

#### 6. Background:

##### Highlights:

Three primary papers on organochlorines in Arctic marine environments were accepted for publication during the year (all to appear in 1992). In addition, a manuscript was prepared and submitted summarizing results from the year-long deployment of two sediment traps from the Ice Island. A video documentary partly filmed on the Ice Island in 1990 during retrieval of the sediment traps was released during the year. This brings to completion the first phase of the project carried out from the Ice Island. Recognition of the value of the work completed was provided by new financial support gained through the Arctic Environment Strategy. Research will continue in a more-productive marine Arctic region near Resolute over the next 5 years.

##### Selected Involvements:

##### i. Collaborative Research -

Co-investigator with R. Moore (Department of Oceanography, Dalhousie University) in NSERC Strategic Grant (1990-1994) (Organobromine Fluxes between the Arctic Atmosphere and Ocean).

##### ii. University Liaison -

Collaboration continued with B. von Bodungen (Kiel University, Germany) through the Canada-Germany Science and Technology Exchange Agreement. Dr. Hargrave spent 2 months (March-April, 1991) in Kiel. Two lectures were presented at Kiel University.

##### iii. Communications -

A 30-minute video documentary (\*Secrets of Ice\*), produced by Breakthrough Films (Toronto, Ont.), was partly filmed on the Ice Island in September 1990. Dr. Hargrave provided a taped interview in Ottawa in January 1991 and assisted in script preparation.

##### iv. Contracts Administered -

##### v. Other -

#### 7. Publications:

##### i. Primary -

##### ii. Interpretive Scientific -

##### iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to make excellent progress and has received substantial Green Plan funding for its continuation. Excellent collaboration at the national and international level.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 722

Section:

Project Title: Instrumentation Support

Project Leader: Reimer, D.P.

Other Researchers:

Work Activity: W.A.1.1.3.1

Key Words: instrumentation; data processing

1. Project Description:

Develop, test, repair, and operate field equipment used to gather habitat and living resource data.

2. Long-Term Objectives:

Facilitate the procurement of field data needed to fulfill the mandate of the Habitat Ecology Division and Biological Sciences Branch.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Provide instrumentation support to field programs in the Habitat Ecology and Marine Fish Divisions (May and June, K. Frank [MFD]; Summer 1991, G.C. Harding, B.T. Hargrave, D.L. Peer, and R. Addison [HED]).

Instrumentation support was provided for both the Habitat Ecology Division (HED) and Marine Fish Division (MFD) by the preparation of the required electronic instrumentation and participation for MFD cruise (April 1991 - K. Frank), provided support for HED cruise (May 1991 - Peer), participated in HED cruise (September 1991 - W.P. Vass), and participated in HED Sled Gear trial (December - T.W. Rowell).

2. Final clean-up of Netminder II systems, standard and miniature systems.

The Netminder II CTD is fully functional. Some work remains regarding modifications to the underwater housing, final sensor connector selection, implementation of commercially etched printed circuit boards, and completing the technical and operating documentation. The miniature systems should be completed by fiscal year end.

3. Final clean-up of thermistor data logger. Discuss possibility of modifications to incorporate more thermistors and/or addition of conductivity.

The Thermistor Data Logger should be completed by February 28, 1992.

4. Completion of acquisition and analysis software development for Netminder II systems.

Not much has been done regarding acquisition software development. Jeff McRuer (MFD, BSB) has not had any time available for this project and I have not progressed sufficiently in Borland C++ language to complete this on my own. I have requested funds for an 'Introduction to C++ programming' course.

5. Completion of instrumented meter block.

The Instrumented Meter Block is still under development. A higher priority will be given to this project next year.

6. Continue involvement in portable winch development.

I was not involved with the Portable Winch project in this current year.

7. Provide assistance in the development of a video system for bottom sampling devices.

Assistance was provided for the video system on the Bottom Sampling Sled.

4. Additional Accomplishments:

1. Provided instrument support for MFD (October to November 1991 - T.C. Lambert) AFAP.

5. Goals/Expected Outputs for 1992:

1. Provide instrumentation support to field programs in the Habitat Ecology and Marine Fish Divisions (MFD: 1992 AFAP Program [T.C. Lambert], November [K. Frank], December [K. Frank], CSS Matthew Gear Trial [K. Frank]; HED: May [W.P. Vass, side-scan], July [G.C. Harding, lobster], September [T.W. Rowell, AFAP - sled]).
2. Completion of instrumented meter block.
3. Completion of acquisition and analysis software development for Netminder II systems.
4. Continue involvement in portable winch development.
5. Provide assistance in the development of a video system for bottom sampling devices.
6. Develop and install external (magnetic) switches for data loggers.
7. Provide supervision and assistance to engineering students doing an Oxygen Sensor project for S.R. Durvasula (HED, BSB).

6. Background:

Highlights:

Selected Involvements:

i. Collaborative Research -

ii. University Liaison -

iii. Communications -

iv. Contracts Administered -

v. Other -

7. Publications:

i. Primary -

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to provide excellent electronic support to field programs in the Biological Sciences Branch.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 723

Section:

Project Title: Ballast Waters as a Source of Algal Blooms

Project Leader: Durvasula, S.R.

Other Researchers: Kerr, S.R.

Work Activity: W.A.1.1.3.2

Key Words: toxic blooms; ballast water; exotic algae

1. Project Description:

There is ample evidence in support of a global spread of toxic (DSP, PSP) algal blooms to the coastal mariculture sites which could be, in part, due to inadvertent transoceanic and interoceanic introduction of harmful unwanted algae through ships' ballast discharges (Kerr, CAFSAC Document 90/34, Ambrose, 1990, Carolton et al. 1990). About 40,000 major ships carry billions of tonnes of ballast waters annually. (Stewart)

A preliminary analysis of the data from our phytoplankton monitoring programme revealed an increase in the frequency of occurrence and succession of toxic algal blooms during summer in and around Nova Scotia which is of interest and could be attributed to general processes of eutrophication and the introduction of seed populations, i.e. cysts or normal cells. Besides inducing toxic algal blooms, these exotic species could also introduce pathogens (Stewart) resulting in a disastrous effect on our aquaculture industry. I flag these recent episodes as anomalous events which merit a detailed systematic study of the taxa, their physiological state, viability, conditions necessary for bloom formation and their potential for toxic episodes.

Consistent with this, the Steering Committee of CAFSAC recommended that studies and experiments be conducted on ballast waters.

2. Long-Term Objectives:

Document algal blooms from representative Canadian Atlantic ports (such as Halifax, Sydney, and Port Hawkesbury) which could be attributable to ballast water discharges and sediments from ballast holdings. Establish toxicity of such blooms.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. As resources permit, sample ballast waters and sediments in ships visiting Nova Scotian ports and identify phytoplankton taxa.

In collaboration with Dr. Sprules (University of Toronto) obtained >56 preserved samples from ballast holdings of ships. These ballast waters originated from far off coasts, i.e. Japan, Mediterranean, Azores, Adriatic, Italy, Baltic, Middle East, South Africa, Caribbean, Indian Ocean, Black Sea, etc. Taxonomic identification of the algae is in progress.

As resources for contractual help for sampling ballast waters and sediments in ships visiting Nova Scotia ports and identifying the taxa are quite modest, this project could not be pursued in full vigour.

2. Isolate and develop cultures of some of the taxa.

Through the courtesy of Dr. Sprules and his associates, six freshly-collected ballast water samples, originating from Antwerp, Greece, Denmark, Algeria, Italy, and the Adriatic Sea were obtained. Isolates of algae were inoculated into sterile culture media, and +12 algal cultures were established.

4. Additional Accomplishments:5. Goals/Expected Outputs for 1992:

1. Complete identification of samples generated by Dr. Sprules. (Durvasula)
2. Sample, isolate, and culture several other algae from ballast waters of ships visiting Nova Scotian ports. (Durvasula)
4. Continued involvement with the ballast water issue is planned, including publication of the summary of the 1991 workshop. (Kerr)

6. Background:

## Highlights:

## Selected Involvements:

## i. Collaborative Research -

Dr. Sprules (University of Toronto) - Identified algae present in preserved ballast water samples.

## ii. University Liaison -

As above.

## iii. Communications -

Presentations at the Ballast Water Workshop (BIO). (Kerr, Durvasula)

Presentation on ballast water to the Canadian Shipping Federation. (Kerr)

Provided interviews on ballast water to the Daily News and ASN and did a 25-minute program for Shaw Cable.

## iv. Contracts Administered -

## v. Other -

Provided advice on ballast water control to Dr. Rigby (BHP Corp., Australia) and the Victoria Committee for Development (Nova Scotia).

Reviewed final report of ballast water study at the request of J. Cooley (DFO, Bayfield Institute).

7. Publications:

## i. Primary -

Amadi, I., D.V. Subba Rao, and Y. Pan. 199 . Red water: *Gonyaulax digitale* bloom in the Bedford Basin, Nova Scotia, Canada. Mar. Biol.: in press.

## ii. Interpretive Scientific -

## iii. Scientific and Technical -

Subba Rao, D.V. 1991. Recent observations of toxic dinoflagellate blooms in Atlantic Canadian waters. 199 . Proc. Canadian Workshop on the Risk to Canada's Marine Resources of Species Introductions Carried in Ships' Ballast Water (April 1991, Dartmouth, N.S.): in press.

## iv. Popular and Miscellaneous -

8. Review and Evaluation:

A successful workshop was held in 1991, and the report will, hopefully, be available in early 1992. Progress on acquiring new data has been limited by financial constraints.

PROGRAM REVIEW, EVALUATION AND PLANNING 1991/92

Division: Habitat Ecology Division

Project No.: 977

Section:

Project Title: Effect of Fishing Activity on Fish Habitat

Project Leader: Vass, W.P.

Other Researchers: Chin-Yee, M.; Gordon, D.C.; Harding, G.C.; Hawryluk, M.; Peer, D.L.; Reimer, D.P.; Rowell, T.W.; Schwinghamer, P.; Steeves, G.; Vine, D.; Woo, P.

Work Activity: W.A.1.1.3.1

Key Words: benthos; habitat research; fishing activity; benthic samplers

1. Project Description:

There has been increasing concern that the operation of some types of fishing gear may affect fish habitat and have a negative influence on the abundance of fish stocks. Quantitative information on this issue is very limited. This project is investigating the impacts of abandoned gillnets (i.e. ghost-fishing) and bottom trawls on fish habitat in Atlantic Canada, both coastal and on the continental shelf.

2. Long-Term Objectives:

To quantify the impacts of abandoned gillnets and bottom trawls on fish habitat and commercial fish stocks, with focus on demersal species, and to recommend mitigative measures to reduce/eliminate negative effects.

3. Goals/Expected Outputs vs. Accomplishments in 1991:

1. Prepare a report on the findings of the 1990 gillnet experiment in St. Margaret's Bay and communicate results to industry and the general public. (Vass and Harding)

This report will be prepared upon the completion of the third field experiment planned for St. Margaret's Bay during the summer of 1992. This experiment will be designed to determine if residence time is correlated with scavenger density.

2. Design and execute a second gillnet experiment employing different environmental conditions (time of year, distance from shore, various bottom types, etc.). (Vass and Harding)

This experiment was completed in August 1991. No correlation between residence time and temperature or fish location relative to the bottom was observed.

3. Plan and conduct a cooperative two week cruise with the Fisheries Development Division (newly named Industry Services and Native Fisheries Branch) (after consultation with fishing industry representatives) to study the abundance and distribution of ghost-nets on the Scotian Shelf. (Vass and Harding)

This research cruise (Sept. 23 to Oct. 3, 1991) concentrated on a search of the northern edge of Georges Bank. This is an area of special concern to industry due to gear conflict. Lost gillnets were encountered during 19 of 236 grapnel tows (8 percent). A report is in preparation. The Industry Services and Native Fisheries Branch did not obtain AFAP funding to permit their participation in this project other than in an advisory capacity. The funding level of this research cruise permitted only a low-tech approach (grapnels) to the search.

4. Prepare a report on the findings of the 1990 Minas Basin trawling experiment and communicate results to industry and the general public. If subvention funding is approved, assist Acadia University in conducting a second trawling experiment during the summer months. (Gordon)

A report on the 1990 experiment was prepared by Acadia University. Subvention funding was awarded to Acadia University and a second experiment was conducted during the summer of 1991. Both experiments showed negligible impacts on benthos, which was dominated by deposit-feeding polychaetes. Preliminary results were presented at a public lecture in Yarmouth, N.S.

5. In collaboration with the Newfoundland Region and the Marine Fish Division, complete the design of the offshore trawling impact study and conduct a 10-day cruise. It is expected that the Scotia-Fundy Region portion of the project will concentrate field work on Management Area A (Emerald and Western Banks) which has been closed to mobile gear for 3 years. Benthic organism samples collected recently in this area under Project 710 will form a good baseline. (Peer and Rowell)

The design of the trawling impact experiment is complete. The study will concentrate on two areas closed to mobile gear: Western Bank, and an area near Hibernia voluntarily closed by industry. The successful research cruise on the Dawson (May 1991) collected samples of benthos in both areas with a

video-equipped epibenthic sled (Thouzeau Sled), a modified, video-equipped van Veen grab, and small box corer. The camera-equipped grab allowed both visual selection of sampling locations and immediate evaluation of the efficiency of individual grabs. The sidescan sonar, provided by AGC (DEMR), furnished detailed records of trawling and dredging activity. Further baseline sampling of megabenthos will be carried out during the 1992 research cruise with experimental trawling and sampling scheduled for 1993.

6. Experiment with different types of imaging and sampling equipment to determine the most effective and efficient methods for measuring the direct, short-term impacts of trawls and dredges on megabenthic species that are important food sources for demersal fish. (Peer, Rowell, Vass, Reimer, Chin-Yee, Vine)

A detailed assessment of video records of the epibenthic sled facilitated the design improvements successfully tested by HED and Engineering and Technical Services (MSB) staff during gear trials on the Dawson (December 1991). Final modifications to the mechanical and video components are in progress. A strengthened roller-block assembly, necessary for the operation of the sled, was constructed and successfully tested. The Engineering and Technical Services Division (Chin-Yee) is completing the design of a compressed air-actuated bottom grab which will be equipped with a color video camera and a forward-looking black and white video camera.

#### 4. Additional Accomplishments:

1. Sorting, identification, and quantification of molluscan samples from the 1991 AFAP cruise have been completed and the data entered into the computer for analysis. Sorting and identification of the remainder of the macrobenthos is underway. Megabenthic data has been entered into the computer. P. Schwinghamer (Newfoundland Region) is currently working up the meiobenthic samples. (Rowell)
2. A van Veen grab was modified and outfitted with a video camera, allowing both visual selection of sampling locations and immediate evaluation of the efficiency of individual grabs. Trial use of this grab and of other gear such as a side-scan sonar and a new (to us) epibenthic sled have subsequently allowed the design of a completely new grab and video system and of major improvements to the epibenthic sled.

#### 5. Goals/Expected Outputs for 1992:

1. Test the feasibility of using a dual-frequency, high-resolution sidescan sonar to map locations of lost gillnets with an experiment near Halifax Harbour. Use the results to determine the feasibility of using this equipment in a gillnet recovery project on Georges Bank. (Vass)
2. Conduct a third gillnet experiment in St. Margaret's Bay with emphasis on the correlation of residence time and scavenger population density. Prepare a report on the findings of the three gill net experiments. (Vass)
3. Completion and field testing of the new grab and video system, the modified epibenthic sled, and a rejuvenated and upgraded BRUTIV. These, in conjunction with sidescan sonar, will provide a powerful new suite of equipment for the trawling impact study as well as future benthic studies. (Rowell, Vass, Reimer, Chin-Yee, Steeves, Vine, McKeown, Harvey, Young, Fader, Miller, Boyce)
4. In collaboration with the Newfoundland Region, plan and conduct a two-week cruise to collect samples of benthos in the two trawling impact study sites (Hibernia and Western Bank). (Rowell)
5. Prepare a scientific paper on the results of the Minas Basin trawling experiments. (Gordon)
6. Preliminary analysis of data resulting from the 1991 and 1992 trawling impact research cruises, as well as earlier relevant data. (Rowell, Woo)

#### 6. Background:

##### Highlights:

In 1991, very significant progress was made in the development of improved sampling gear and in the testing of this equipment, and of sampling regimes during the first cruise of the trawling impact study. The highly successful cruise on the Scotian Shelf and Grand Banks has provided the basis for further gear development for use in this and other benthic studies.

The ghost-net cruise to Georges Bank confirmed concerns expressed by the fishing industry about concentrations of lost gillnets in certain areas on Georges Bank.

##### Selected Involvements:

##### i. Collaborative Research -

C. Cooper and Bill Hickey (Fisheries and Habitat Management)  
 P. Schwinghamer and M. Hawryluk (Newfoundland Region)  
 G. Fader, B. Miller, and A. Boyce (AGC, DEMR)  
 M. Chin-Yee, G. Steeves and D. Vine (ETS, MSB)  
 D. McKeown, D. Harvey, and S. Young (Metrology Division, PCS)  
 D. Marcogliese (Quebec Region)

##### ii. University Liaison -

M. Brylinsky (Acadia University)

##### iii. Communications -

Progress reported in monthly AFAP reports.

Attended Fixed Gear Working Group meeting (November 1991).

iv. Contracts Administered -

Arenicola Marine - for the identification and enumeration of invertebrates from benthic samples (two contracts) - \$6.0 K. (Rowell)

Maritime Testing (1985) Ltd. - for molluscan sorting and identification (Dawson 1991 research cruise) - \$0.9 K. (Rowell)

v. Other -

Shelburne Co. Longliners Association (Noble Smith) - This group was involved in the planning and assisted in the first leg of the lost gillnet cruise on Georges Bank.

7. Publications:

i. Primary -

Messieh, S.N., T.W. Rowell, D.L. Peer, and P.J. Cranford. 1991. The effects of trawling, dredging, and ocean dumping on the eastern Canadian continental shelf. Cont. Shelf Res. 11(8-10): 1237-1263.

ii. Interpretive Scientific -

iii. Scientific and Technical -

iv. Popular and Miscellaneous -

8. Review and Evaluation:

This project continues to gain momentum and is critically dependent upon collaboration with other research and engineering groups. The previous project leader for the trawling component, Mr. Peer, retired in June, but his role has been picked up by Mr. Rowell. This project was assisted by a six-month career assignment involving a technician from the Marine Fish Division. Communication with industry has been excellent. Progress was hindered by a callback of AFAP funds in September.

## INDEX

## Key Words

- abundance 82, 122  
 abundance indices 90  
 acid rain 235, 261, 266  
 acoustics 87, 318  
 administration 1, 3, 5, 10, 105,  
 171, 173, 179, 222, 232, 290, 337  
 advice 337, 339  
 age determination 70  
 ageing 76  
 alewife 210, 238  
 algae 181  
 all terrain vehicles 57  
 aquaculture 181, 184, 187, 190, 192,  
 198, 219, 224, 227, 242, 245,  
 249, 252, 258, 269, 341, 344,  
 346, 368  
 Arctic Ocean 387  
 Arctic research 325, 327, 334  
 Argentine 47  
 Ascophyllum 153  
 assessment research 13, 17, 28, 30,  
 32, 34, 36, 39, 42, 47, 59, 73,  
 76, 80, 87, 127, 143, 146, 151,  
 153, 155, 157, 159, 162, 164,  
 166, 175, 205, 272, 275, 281, 287  
 assessment-related research 20, 22,  
 25  
 assessments 13, 20, 22, 25, 28, 30,  
 32, 34, 36, 39, 42, 62, 65, 68,  
 70, 139, 143, 146, 151, 153, 155,  
 157, 164, 166, 175, 205, 210,  
 230, 272, 278  
 Atlantic Fisheries Adjustment Program  
 131  
 Atlantic salmon 235, 266  
 Atlantic salmon enhancement 224, 227  
 availability 82  
 bacteria 310, 329, 341  
 ballast water 376, 392  
 Bay of Fundy 13  
 benthic habitat research 384  
 benthic samplers 394  
 benthos 258, 366, 368, 394  
 bioenergetics 376  
 biological oceanography 90, 303,  
 305, 308, 310, 312, 314, 316,  
 318, 320, 323, 325, 327, 329, 332  
 biomonitoring 235  
 biostatistics 230  
 bivalve 196  
 BKD 187, 198  
 bottom trawl 122  
 CAFSAC 5  
 capelin 73  
 Chondrus 153, 155  
 clams 146, 272, 355  
 climate changes 312, 320  
 cod 28, 30, 32, 34, 73, 76, 119,  
 124, 255  
 collection 298  
 commercial sampling 13, 62, 65  
 computer 136  
 computer centre 292  
 computer model 235  
 computing 5  
 consultation 129  
 contaminants 359, 384, 387  
 crabs 151  
 data processing 96, 105, 136, 177,  
 179, 222, 230, 232, 292, 390  
 deep water fauna 47  
 diadromous fish 210  
 diagnostics 187, 190, 198  
 diets 52, 131  
 direction 3  
 distribution 114, 124  
 Division administration 203  
 domoic acid 192, 252, 344, 346  
 dynamics 116  
 early life history 141  
 ecological modelling 381  
 ecology 148, 272, 275, 287  
 ecology and evolution 100  
 ecophysiology 196  
 ecosystem integrity 376  
 eels 210  
 energetics 52  
 environmental baseline and monitoring  
 298  
 ESP 114, 124  
 essential fatty acids 181  
 evaluation 379  
 exotic algae 392  
 experimental design 111, 169  
 field stations 57  
 financial management 337  
 FINS 129  
 fish disease 187, 190, 198  
 fish distribution 80, 82, 90  
 fish food 184  
 fish health 198  
 fish migrations 80  
 fish passage 216  
 fisheries ecology 73, 76, 90, 103,  
 139  
 fisheries interactions 373  
 fishermen 129  
 fishing activity 394  
 fishways 216  
 flatfish 44  
 food consumption 52  
 foreign fishery 39  
 functional morphology 298  
 furunculosis 187, 198  
 gadids 116  
 gaspereau 210, 238  
 genetics 114, 245  
 Georges Bank 17, 124  
 GIS 379  
 groundfish 20, 22, 25, 28, 30, 32,  
 34, 36, 39, 42, 44, 59, 62, 65,  
 68, 70, 80, 90, 94, 103, 114,  
 119, 122, 124, 127  
 Gulf of Maine 124, 166  
 habitat 5, 337, 339, 373  
 habitat ecology 242  
 habitat evaluation 381  
 habitat production 379  
 habitat research 159, 238, 258, 341,  
 344, 346, 349, 352, 355, 359,  
 363, 366, 368, 371, 376, 387, 394  
 habitat sensitivity mapping 379  
 haddock 22, 25, 124, 255  
 haddock biology 20  
 halibut 44, 255  
 harvesting 116  
 hatcheries 213, 219, 224, 227  
 heritability 376  
 herring 13, 17, 87, 100  
 hydroacoustic 122  
 ice algae 334  
 ichthyoplankton 13, 17, 73  
 identification 298  
 immunology 187  
 index estimates 122  
 informatics 232  
 inshore lobster 166  
 instrumentation 390  
 international observers 39, 42  
 invertebrate fisheries 242  
 invertebrate larvae 139  
 invertebrates 269  
 Irish moss 153, 155  
 juvenile habitat 141  
 juvenile surveys 39, 73, 94  
 kelp 352  
 Laminaria 153  
 large pelagics research 84  
 larvae 73, 162, 318  
 LFA 31-32 164  
 LFA 34 166  
 LFA 40-41 157  
 life history 116, 298  
 liming 235  
 lipids 181  
 lobster 151, 159, 162, 164, 175,  
 181, 278, 281, 363  
 lobster biology 141, 157, 166, 284  
 mapping 177

- marine fish 181  
 marine fish culture 255, 263  
 marine mammal/fisheries interactions 52  
 marine mammals 49, 373  
 marine plants 153, 155, 352  
 mesopelagic assessments 47  
 metabolism 181  
 microbial degradation 344  
 microbiology 329, 341  
 microcosms 346  
 microparticle 196  
 migration 124  
 mitigation 216, 235, 238  
 modelling 90, 314, 332, 376  
 molluscan culture 192  
 monitoring 379  
 morphometric analyses 148  
 mussels 175, 192  
*Mytilus edulis* 175  
 NAFO 4TVW 20  
 NAFO 4Vn 13, 28  
 NAFO 4Vsw 30  
 NAFO 4VWX 36, 39, 42, 44  
 NAFO 4WX 13  
 NAFO 4X 22, 32  
 NAFO 5Z 17  
 NAFO 5Zc 36  
 NAFO 5Ze 25, 34  
 near-bed particle field 359  
 nutrient stress 346  
 nutrition 181, 184, 192, 196, 323  
 offshore lobster 157  
 organization 129  
 organochlorines 363  
 otolith 76  
 oysters 192  
 paralytic shellfish poisons (PSP) 344  
 parasitology 49, 190, 298  
 particle tracking 90  
 particle transport 359  
 particle-aggregate studies 329  
 pelagic fish 13, 17, 90, 100  
 perturbations 346  
 phycotoxin 349  
 physical oceanography 90  
 physiology 249  
 phytoplankton 303, 305, 310, 312, 320, 349  
 phytotoxins 192, 252  
 plaice 44  
 planning 173  
 pollock 36  
 population biology 298  
 population dynamics 139  
 primary production 303, 305, 308, 312, 320, 334, 352  
 PSP 252  
 recovery 266  
 recruitment 73, 76, 90, 94, 116, 141, 162, 281  
 redfish 42  
 research 116, 119  
 research direction 203  
 research vessel 294, 296  
 resource management 116  
 resource surveys 13, 17, 36, 62, 65, 68, 87, 94, 96, 143, 146, 177  
 Sable Island 49, 57  
 salmon 184, 187, 198, 205, 230, 238, 245, 249, 261, 263  
 salmon enhancement 213, 216, 219, 238  
 salmonid culture 245, 249  
 sampling 111, 169  
 scallop assessment 148  
 scallop genetics 148  
 scallops 143, 146, 181, 192, 275, 359  
 scientific management 337  
 Seal-Sealworm Ecology Program 49, 52  
 seals 49, 52, 57, 131, 373  
 sealworm 49, 52  
 sealworm abundance 131  
 secondary production 314, 316, 318, 323, 325, 327, 334  
 shad 210  
 shellfish 196  
 silver hake 39  
 size-dependent production processes 82  
 Southwest Nova Scotia 166  
 SPANS 124  
 spatial distribution 124  
 statistical advice 292  
 statistical analysis 169  
 statistics 111  
 stock assessment 122  
 stock structure 114, 157, 166  
 striped bass 210  
 striped bass culture 263  
 Subarea 4 114  
 support 136  
 survey research 111  
 surveys 122  
 swordfish assessment 84  
 synthetic diets 196  
 systematics 298  
 tagging 80  
 taxonomy 298  
 technical support services 290  
 toxic algae 349  
 toxic blooms 392  
 transport 90  
 underutilized invertebrates 287  
 underutilized species 47  
 whales 373  
 winter flounder 44  
 winter research 334  
 wireweed *Furcellaria* 155  
 witch flounder 44  
 yellowtail flounder 44  
 zoogeography 298  
 zooplankton 314, 316, 318, 323, 325, 327, 334, 363
- Other Researchers**  
 Aiken, D. 284  
 Aitken, D. 224, 227  
 Amiro, P. 205, 213, 232  
 Annand, C. 116  
 Austin, W. 224, 227  
 Banks, M. 294  
 Beanlands, D. 36, 70  
 Bellis, S. 292  
 Best, B. 290  
 Black, G. 143  
 Boston, L. 181  
 Boudreau, P.R. 82, 232, 238, 376  
 Bourbonnais, C. 70  
 Bowen, D. 10, 111  
 Bradford, B. 192, 196  
 Branton, R. 96, 177  
 Brown, L. 68, 70, 116  
 Buerkle, U. 122  
 Butler, M. 143  
 Buzeta, M. 34, 70, 116, 119, 124  
 Carney, C. 290  
 Chandler, R. 272, 275, 287  
 Chang, B. 242  
 Charlton, B. 105  
 Chin-Yee, M. 394  
 Clark, D. 122  
 Claytor, R. 245  
 Conover, R.J. 387  
 Conrad, V. 216  
 Covey, M. 173  
 Cutting, R. 205, 210, 230, 232  
 Dale, C. 70  
 Daly, J. 187  
 Decker, T. 62  
 Dickie, P. 310  
 Dickson, C. 84, 87  
 Donaldson, G. 62  
 Dougherty, W. 13  
 Drinkwater, K. 90  
 Duggan, D. 141, 157, 166  
 Duggan, R. 139, 162, 164  
 Dunfield, R. 224  
 Durvasula, S.R. 344, 349, 352, 381  
 Duston, J. 249  
 Eagles, M. 151  
 Fanning, P. 59  
 Farmer, G. 213, 245

Fawkes, G. 242  
 Fawkes, S. 292  
 Fennel, J. 62  
 Field, B. 173  
 Fife, J. 13  
 Fildes, J. 187  
 Foda, A. 329  
 Frank, K. 10, 22, 124  
 Freeman, K. 192  
 Gale, J. 68, 105, 122  
 Gavaris, S. 10, 59, 68, 90, 111, 119, 124  
 Goff, T. 224, 227  
 Gordon, D.C. 359, 381, 394  
 Gordon, J. 13  
 Greenberg, D. 90  
 Guilcher, D. 3  
 Guilderson, J. 1  
 Guptill, Capt. F. 296  
 Halliday, R. 10  
 Hamel, J. 32, 70, 76  
 Harding, G.C. 387, 394  
 Hargrave, B.T. 366, 368, 381  
 Harmon, P. 249  
 Harrie, K. 3  
 Harris, L. 323, 325, 327, 334  
 Harrison, W. 312  
 Harvie, C. 230, 232  
 Hatt, B. 292  
 Haughn, D. 294  
 Hawryluk, M. 394  
 Henderson, J. 1  
 Hogans, W. 298  
 Hovey, A. 249  
 Howes, K. 255  
 Hubley, P. 219  
 Hudon, C. 166  
 Hunt, J. 59, 119, 122, 124  
 Hunter, C. 139, 177  
 Hurley, J. 290  
 Hurley, P. 73, 119  
 Iles, D. 116  
 Jansen, H. 213  
 Jessop, B. 205, 213, 230  
 Jones, D. 155  
 Kean-Howie, J. 192  
 Keith, R. 184  
 Keizer, P.D. 337, 359, 379, 381  
 Kenchington, E. 146  
 Kennedy, M. 318  
 Kerr, S.R. 82, 392  
 Knox, J.D. 249  
 Koeller, P. 5, 39, 68  
 Lacroix, G. 261  
 Lambert, T. 114, 119  
 Lavoie, R.E. 3  
 Leger, J. 190  
 Lim, S. 298  
 Loder, J. 90  
 Losier, R. 90, 96  
 Lough, G. 90  
 Lumsden, D. 294  
 Lundy, M. 148  
 Lynch, D. 90  
 Lyon, D. 62  
 MacEachern, W. 70  
 MacKinnon, A-M. 198  
 Maguire, J.-J. 5  
 Marks, L.J. 341, 344  
 Marryatt, V. 190  
 Marshall, L. 213, 230, 232  
 Martell, J. 49  
 Martin, J.D. 272, 275, 287  
 Martin, J.L. 252, 258  
 Martin-Robichaud, D. 261, 263  
 McAskill, J. 224, 227  
 McClelland, G. 131  
 McMenemy, M. 198  
 McMillan, J. 105  
 McRuer, J. 22, 73  
 Melvin, G. 13  
 Messieh, S.N. 381  
 MFD Staff 129  
 Miller, R. 151, 162  
 Miner, Capt. W. 296  
 Mohn, R. 59, 124  
 Moore, A. 187  
 Morgan, J. 116  
 Morgan, S.P. 337  
 Neilson, J. 34, 80, 116, 119  
 Nelson, C. 70  
 Newbould, K. 230  
 Nolan, S. 159  
 O'Neil, S. 205, 213  
 Olivier, G. 245  
 Orr, E.A. 349  
 Page, F. 25, 116  
 Parnell, J.E. 337  
 Parsons, J. 275  
 Peer, D.L. 355, 366, 384, 394  
 Penney, G. 227  
 Perley, P. 44, 70, 94  
 Perry, I. 68, 90, 124  
 Peterson, R. 116, 245  
 Pezzack, D. 139, 141  
 Phillips, G.A. 384, 387  
 Pitre, R. 294  
 Platt, T. 305, 332  
 Pohle, G. 298  
 Polar, S. 290  
 Porteous, D. 5  
 Power, M. 13  
 Pringle, J. 153, 155  
 Reid, J. 96, 255  
 Reimer, D.P. 363, 394  
 Ritter, J. 205, 210, 213, 222, 235, 245  
 Robert, G. 177  
 Robichaud, D. 278, 281, 287  
 Robicheau, R. 70  
 Roddick, D. 148, 159  
 Rowell, T.W. 272, 337, 394  
 Sampson, H. 70  
 Saunders, R. 245  
 Schwinghamer, P. 366, 394  
 Seibert, G. 5  
 Semple, R. 153, 155, 175  
 Shellnutt, S. 173  
 Showell, M. 39, 59, 65, 124  
 Silvert, W.L. 376, 379  
 Simon, J. 70, 96  
 Sinclair, M. 90, 139  
 Smith, P. 90  
 Smith, S. 36, 90  
 Smith, W. 62  
 Sochasky, J. 13  
 Staff, Habitat Ecology Division 339  
 Steeves, G. 394  
 Stephenson, R. 10, 59, 90  
 Stewart, J.E. 346  
 Stobo, W. 57, 111, 131  
 Strong, M. 68, 70, 122  
 Tee, K. 90  
 Thorpe, B. 278  
 Thouzeau, G. 143  
 Tremblay, J. 90  
 Trippel, E. 25, 119, 124  
 Trynor, J. 87  
 Van Eeckhaute, L. 25, 70, 116, 119, 124  
 Van Guelpen, L. 298  
 Vass, W.P. 162, 337, 363, 387  
 Vine, D. 394  
 Waddy, S. 269  
 Waldron, D. 59, 124  
 Watson, N. 235  
 Welch, H.E. 387  
 Wentzell, C. 173  
 Werner, F. 90  
 White, W. 235, 238  
 Williams, D. 198  
 Williamson, A. 278  
 Wilson, A. 252, 258  
 Woo, P. 355, 366, 394  
 Yeats, P. 346  
 Young, E. 224, 227  
 Young, G. 62, 70  
 Zwanenburg, K. 42, 94, 124  
 Zwicker, B. 198  
 Project Leader  
 Aiken, D. 269  
 Annand, C. 36, 44, 70  
 Black, G. 177  
 Boudreau, P.R. 379

- Bowen, D. 52, 57, 131  
 Branton, R. 105  
 Brodie, P.F. 373  
 Buerkle, U. 87  
 Campana, S. 32, 76  
 Castell, J. 181  
 Conover, R. 316, 325, 334  
 Cook, R. 242, 245, 298  
 Cornick, J. 198  
 Cranford, P.J. 359  
 Cutting, R. 213, 222  
 Dickie, L. 82  
 Durvasula, S.R. 346, 392  
 Fanning, P. 30  
 Farmer, G. 224, 227  
 Frank, K. 73  
 Gale, J. 105  
 Gavaris, S. 25, 122  
 Gordon, D.C. 337, 339  
 Halliday, R. 47, 59, 127  
 Harding, G.C. 162, 363  
 Hargrave, B.T. 384, 387  
 Harrison, W. 305  
 Head, E. 323, 327  
 Horne, E. 308  
 Hudon, C. 141  
 Hunt, J. 34, 68, 70  
 Hurley, P. 22  
 Iles, D. 100  
 Jansen, H. 216, 219  
 Jessop, B. 210  
 Kean-Howie, J. 196  
 Keizer, P.D. 349, 368  
 Kenchington, E. (nee Rice) 148  
 Kepkay, P. 329  
 Kerr, S.R. 376  
 Lacroix, G. 266  
 Lall, S. 184  
 Lambert, T. 28, 103  
 Lawton, P. 278, 281, 287  
 Li, W. 310  
 Longhurst, A. 314, 320  
 MacPhee, S.B. 1  
 Mann, K.H. 352  
 Marshall, T. 205  
 McClelland, G. 49  
 McRuer, J. 96  
 Melvin, G. 17  
 Messieh, S.N. 371  
 Miller, R.J. 159  
 Mohn, R. 30  
 Morrison, C. 190  
 Neilson, J. 44, 94  
 Nicholls, H.B. 5  
 O'Boyle, R. 10, 42, 119, 124, 129  
 O'Neil, S. 230, 232  
 Olivier, G. 187  
 Page, F. 90, 96  
 Peterson, R. 261, 263  
 Pezzack, D. 157, 166  
 Platt, T. 303, 312  
 Porter, J. 84  
 Pringle, J. 162, 164, 173  
 Reimer, D.P. 390  
 Ritter, J. 203  
 Robert, G. 143, 171  
 Robinson, S. 272, 275, 287  
 Roddick, D. 146  
 Rodger, R. 169  
 Rowell, T.W. 355, 366  
 Sameoto, D. 318  
 Saunders, R. 249  
 Scarratt, D. 179, 192  
 Sharp, G. 153, 155, 175  
 Silvert, W.L. 381  
 Sinclair, M. 3  
 Smith, S. 111  
 Stephenson, R. 13  
 Stewart, J.E. 341, 344  
 Stobo, W. 55, 80, 133  
 Sulak, K. 298  
 Swetnam, D. 136  
 Tremblay, J. 139, 151  
 Trippel, E. 116  
 Vass, W.P. 394  
 Waddy, S. 284  
 Waiwood, B. 290, 292, 294, 296  
 Waiwood, K. 255  
 Waldron, D. 39, 65  
 Watt, W. 235, 238  
 Wheelhouse, J. 7  
 White, G. 332  
 Wildish, D. 252, 258  
 Zwanenburg, K. 20, 62, 114
- Project Title  
 4X Cod Assessment and Associated Research 32  
 4X Haddock Assessments and Associated Research 22  
 5Z Cod Assessments and Associated Research 34  
 Acid Rain Research 235  
 Administration - Aquaculture Section 179  
 Administration and Support Services 290  
 Anadromous Species Statistical Consulting and Data Collection a 230  
 Analysis of Pelagic Ecosystem Structure 314  
 Aquaculture Ecology Research 258  
 Atlantic Reference Centre 298  
 Ballast Waters as a Source of Algal Blooms 392  
 Benthic Habitat Studies 366  
 Benthic/Pelagic Exchanges 368  
 Bio-Optical Properties of Pelagic Oceans 303  
 Bioenergetics of Marine Mammals 373  
 Biological Science Ships 7  
 Biological Stratification in the Ocean and Global Carbon Flux 320  
 Cape Breton Crustacean Assessment and Research 151  
 Carbon and Nitrogen Utilization by Zooplankton and Factors Cont 316  
 Carbon Dioxide and Climate: Biogeochemical Cycles in the Ocean 312  
 Cod Assessments and Associated Research in Division 4VsW 30  
 Cod Assessments and Associated Research in Subdivision 4Vn 28  
 Communications - Fishermen 129  
 Computer Center 292  
 Contaminant Fluxes in Marine Benthic Food Webs 384  
 Continental Shelf Margin Studies Including Argentine Assessment 47  
 Coordination, Aquaculture and Invertebrate Fisheries Program 242  
 Director, Biological Sciences Branch 3  
 Division Administration 10, 203  
 Division/Laboratory Administration 173  
 Divisional Informatics 232  
 Dynamics of Microbial Metabolism and Particle Flux 329  
 Dynamics of Recruitment Processes for Gulf of Maine Gadids 116  
 Ecosystem Size Process 82  
 EDP Support 105  
 Effect of Fishing Activity on Fish Habitat 394  
 Effects of Acid Rain Control Programs on Salmonid Recovery 266  
 Effects of Low pH on Salmonid Development 261  
 Enhancement and Fish Passage Engineering 216  
 Environmental Requirements for Early Fish Development 263  
 Evaluation of Estuarine and Continental Shelf Habitats 381  
 Finfish and Invertebrate Introductions and Transfers 222  
 Finfish Tagging Studies 80  
 Fish and Habitat Interactions 371  
 Fish Culture Engineering 219  
 Fish Culture Research 227

- Fish Disease Research 187  
 Fish Habitat Assessment Advice 337,  
 339  
 Fish Health Services Unit 198  
 Fish Nutrition 184  
 Fisheries Recruitment Variability 73  
 Flatfish Assessments and Associated  
 Research 44  
 Freshwater Fish Habitat Assessment  
 and Related Research 238  
 Groundfish Age Determination 70  
 Groundfish Ecosystem - Harvesting  
 Data 119  
 Groundfish Ecosystems: Research  
 Information - Geographic Distri  
 124  
 Groundfish Ecosystems: Research  
 Information-Survey Data 122  
 Groundfish Management Research 59  
 Groundfish Trawl Surveys 68  
 Habitat of Geographic Information  
 Systems (GIS) 379  
 Haddock Assessments and Associated  
 Research (4TW, 4X, 5Ze) 20  
 Haddock Assessments and Associated  
 Research 5Ze 25  
 Hatchery Operations and Production  
 224  
 Herring Assessment and Associated  
 Research (Subarea 5) 17  
 Herring Assessments and Associated  
 Research (Subarea 4) 13  
 Informatics 136  
 Inshore Molluscan Habitat Studies  
 355  
 Instrumentation Support 390  
 International Observer Program 65  
 Invertebrate Biology 284  
 Invertebrate Fisheries and  
 Aquaculture Research 269  
 Invertebrate Nutrition 181  
 Juvenile Fish Ecology and Surveys 94  
 Kelp and Seagrass Habitat Studies  
 352  
 Large Pelagics Assessment and  
 Associated Research 84  
 Larval Ecology and Lobster Assessment  
 (LFA 33) 139  
 Lobster Assessment and Related  
 Research in LFA 34 166  
 Lobster Habitat Research and  
 Assessment Methodology 159  
 Lobster Resource Science 141  
 Lobster Resource Science - Larval  
 Biology 162  
 Lobster Resource Science and  
 Assessment - LFA 31 and 32 164  
 Lobster Stock Assessment (LFA 40-41)  
 and Related Research 157  
 Lobster Stock Assessment (LFA's 35,  
 36 and 38) 278  
 Longliner Project - AFAP 127  
 Marine Assessment & Liaison 5  
 Marine Finfish Aquaculture 255  
 Marine Plants Assessment and Research  
 153  
 Marine Plants Assessment and Research  
 - Gulf Region 155  
 Mathematical Models of Marine Pelagic  
 Communities 332  
 Microbial Ecology 341  
 Microbial-Marine Toxin Interactions  
 344  
 Molluscan Culture and Phytotoxin  
 Research 192  
 National Sampling Program 62  
 Non-Salmonid Assessment Research 210  
 Nutrition and Biochemistry in Marine  
 Zooplankton 233  
 Oceanographic Data Handling 96  
 Oceanography and Fish Distribution  
 90  
 Offshore Clams Assessment and  
 Research 146  
 Organochlorines in Arctic Ocean  
 Marine Food Webs 387  
 Otolith Studies 76  
 Parasitology 190  
 Pelagic Acoustics Surveys 87  
 Pelagic Fisheries Management Studies  
 100  
 Physical Oceanography of Selected  
 Features in Connection with M  
 308  
 Physiological Ecology of Toxic Algae  
 346  
 Physiology of Marine Microorganisms  
 310  
 Phytoplankton Monitoring Program -  
 Nova Scotia 349  
 Phytotoxin Research 252  
 Pollock Assessment and Associated  
 Research 36  
 Population Dynamics and Ecology of  
 Bay of Fundy Lobsters 281  
 Population Ecology of Sealworm 49  
 Redfish Assessments and Associated  
 Research 42  
 Regional Director, Science Sector 1  
 Reproductive Strategies of Marine  
 Fish 103  
 Resource Mapping and Special Projects  
 177  
 Resource Potential of Underutilized  
 Invertebrate Species 287  
 Respiration, Nutrient Uptake, Regen.  
 of Natural Plankton Pop. 305  
 S/V J.L. HART 294  
 S/V PANDALUS III 296  
 Salmon Assessment Research 205  
 Salmon Enhancement Research  
 (Enhancement Biology) 213  
 Salmon Genetics Research Program 245  
 Salmonid Growth, Smolting and  
 Reproduction 249  
 Scallop Assessment and Research 143  
 Scallop Habitat Research 359  
 Scallop Population Dynamics and  
 Assessment 275  
 Scallop Research 148  
 Seal Diet and Energetics 52  
 Seal Population Dynamics 55  
 Seal Population Monitoring 133  
 Seal Research Infrastructure 57  
 Seal/Sealworm Ecology - Diet/Parasite  
 Studies 131  
 Secondary Production and the Dynamic  
 Distribution of Micronekto 318  
 Section Administration 171  
 Shore-Based Studies of Under-Ice  
 Epontic and Pelagic Plankton C  
 325  
 Silver Hake Assessments and  
 Associated Research 39  
 Size-Dependent, Bioenergetic  
 Processes in Fish Habitat 376  
 Soft-Shell Clam Fishery Research 272  
 Statistical Consulting 169  
 Statistical Research and  
 Collaborative Studies 111  
 Stock Structure Studies 114  
 Summertime Shipboard Studies in the  
 Eastern Canadian Arctic 327  
 Wild Mussel Resources Assessment and  
 Research 175  
 Year Round Plankton Research in the  
 Arctic 334  
 Zooplankton Habitat Studies 363  
 Work Activity  
 W.A.1.1.1 10, 203  
 W.A.1.1.1.1 205, 210, 222, 230, 232,  
 298  
 W.A.1.1.1.2 20, 22, 25, 28, 30, 32,  
 34, 36, 39, 42, 44, 47, 59, 62,  
 65, 68, 70, 76, 80, 90, 94, 96,  
 103, 111, 114, 119, 122, 124,  
 127, 141, 298  
 W.A.1.1.1.3 136, 139, 143, 146, 148,  
 151, 157, 159, 162, 164, 166,  
 169, 171, 173, 175, 177, 242,  
 272, 275, 278, 281, 284, 287, 298  
 W.A.1.1.1.4 52, 55, 133  
 W.A.1.1.1.5 153, 155  
 W.A.1.1.1.6 13, 17, 84, 87, 100, 298

W.A.1.1.1.7 49, 73, 82, 96, 116,  
192, 298  
W.A.1.1.1.8 303, 305, 308, 310, 312,  
314, 316, 318, 320, 323, 325,  
327, 329, 332, 334  
W.A.1.1.2.1 173, 179, 187, 190, 198  
W.A.1.1.2.2 192, 196, 242, 245, 249,  
255, 263, 269  
W.A.1.1.2.3 173, 179, 181, 184  
W.A.1.1.2.4 213, 216, 219, 224, 227  
W.A.1.1.3.1 238, 337, 339, 352, 355,  
363, 366, 368, 371, 373, 376,  
379, 381, 390, 394  
W.A.1.1.3.2 235, 242, 261, 266, 341,  
344, 346, 349, 359, 384, 387, 392  
W.A.1.1.3.3 252  
W.A.1.1.3.5 258  
W.A.1.1.5 1, 3, 5, 7