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

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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, Stoney 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

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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 CAFSAC research document for ACFF 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, Datmouth, 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

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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 -

Effected 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

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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

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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

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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

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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 relating 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

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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 preovigerous 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 commerical 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 Lousiana 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

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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

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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:

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:

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: Waiwood, B.

Other Researchers: Bellis, S.; Fawkes, S.; Hatt, B.

Work Activity: W.A.1.1.5.0

Key Words: computer centre; data processing; statistical advice

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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

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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

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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

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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 acquaculture 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 (CLOFETA) (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

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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 Valcartier 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: W.A.1.1.1.8

Key Words: phytoplankton; biological oceanography; primary production

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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 instrumention/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 worlds oceans.
8. Participated in AGU-sponsored workshop on analysis and characterization of marine particles in January.
9. Participated in AES-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

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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

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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

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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 5×10^{10} tons CO_2 annually, or more than the entire input of CO_2 into the atmosphere from burning of fossil fuels. The increasing input of 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 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_2 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.

Quiñones, 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

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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

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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

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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 vigourously, 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

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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 LHPR 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 NW 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_2) 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

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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

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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 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 $\mu g\ M^{-2}$ were common. Despite the large biomass of pigment, nitrate concentrations were still in excess of 5 $mmol\ m^{-3}$ 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

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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

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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_2. It also regulates the flux of CO_2 between new and regenerated primary production. Given the possibility that primary production can sequester excess atmospheric CO_2 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_2 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_2 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_2 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 and regenerated production; (iii) The short-term flux of CO_2 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_2 and the rate of CO_2 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 detained 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. *Dep-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

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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_2 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 algae

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1. 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 particulary 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

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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. Stanislow 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

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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

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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 convertors 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 *Aerommas salmonicide* 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)

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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

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1. Project Description:

Data from the phytoplankton monitoring program showed the occurrence of Nitzschia pungens f. multiseries 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. *multiseries*. 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. *multiseries*. 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. *multiseries* 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. *multiseries*.

3. Set up laboratory-scale experimental microcosms similar to Vat immersion core illumination incubator (Wohlgeschaffen, 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. *multiseries*.

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. *multiseries*.

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. Wholgeschaffen 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. Wholgeschaffen: 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. *multiseries* 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.

Wohlgeschaffen, 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* (Bacillariophyseae) 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. *multiseries*. 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. *multiseries* 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

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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

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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 PDF), 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

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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 prefered 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 du 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 fishermens' 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 fishermens' 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 resourse.

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 throught 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 withdrawl 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. Ocean: 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. 25th 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

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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 by 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 26th 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 (Adelphi 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 26th 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 VOCM 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

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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

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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

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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 weir 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

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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-Sabh, 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

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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: W.A.1.1.3.1

Key Words: modelling; habitat research; bioenergetics; heritability; ballast water; ecosystem integrity

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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.

Thiebaux, 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

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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

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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 79th 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 Investigaçao 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

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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 2nd 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 Rockerfeller 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}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 Excellent (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

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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 PDF and three graduate students. Advice has been provided on the role of epontic algae and benthic fauna in mediating transfers and transformations of organohalogens 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 (DFO 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

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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 Thermister 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

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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

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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