ENVIRONMENT CANADA

FISHERIES AND MARINE SERVICE

FISHERIES RESEARCH AND DEVELOPMENT DIRECTORATE

ANNUAL REPORT

OF THE

PACIFIC ENVIRONMENT INSTITUTE
West Vancouver, B.C.

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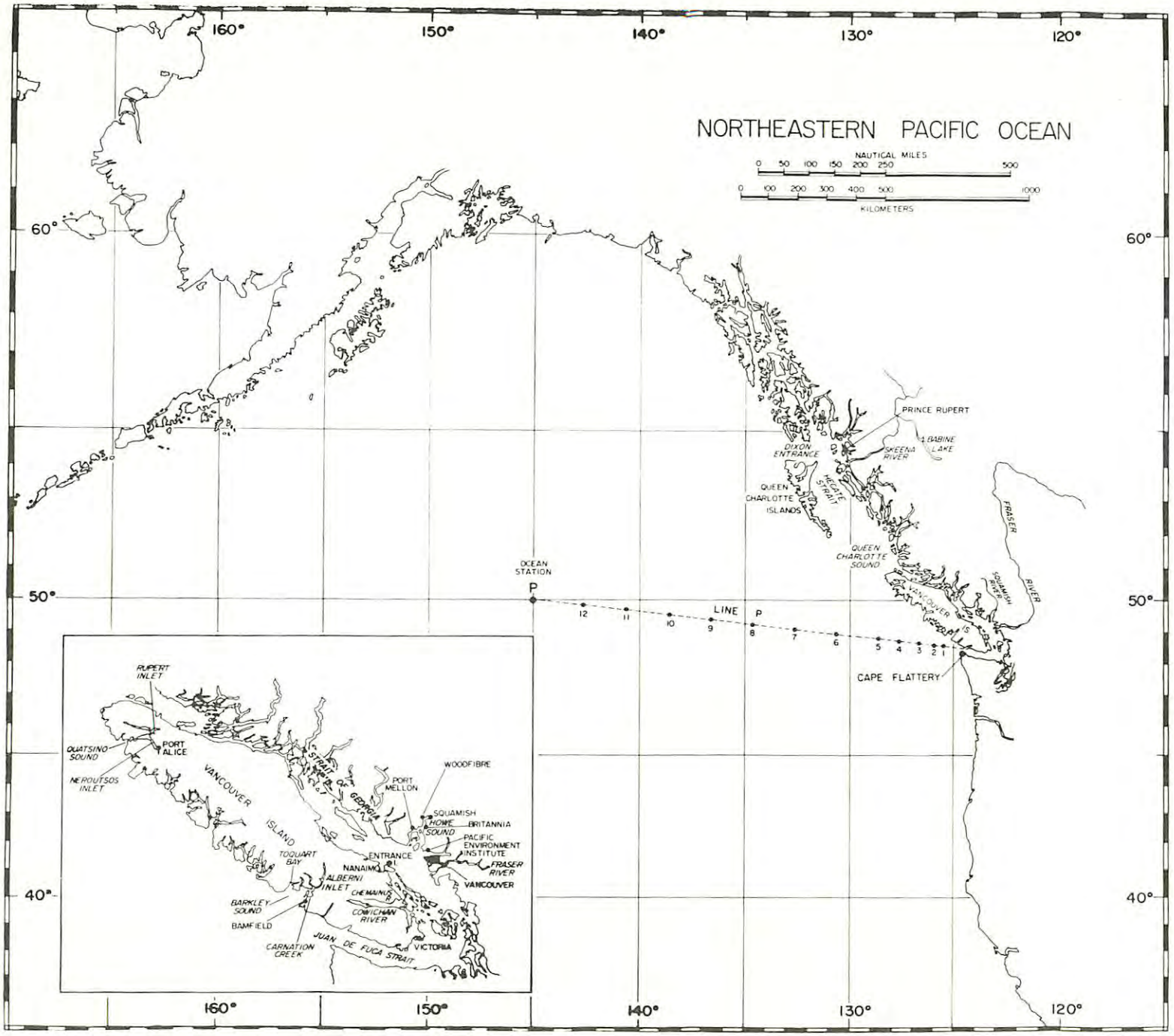
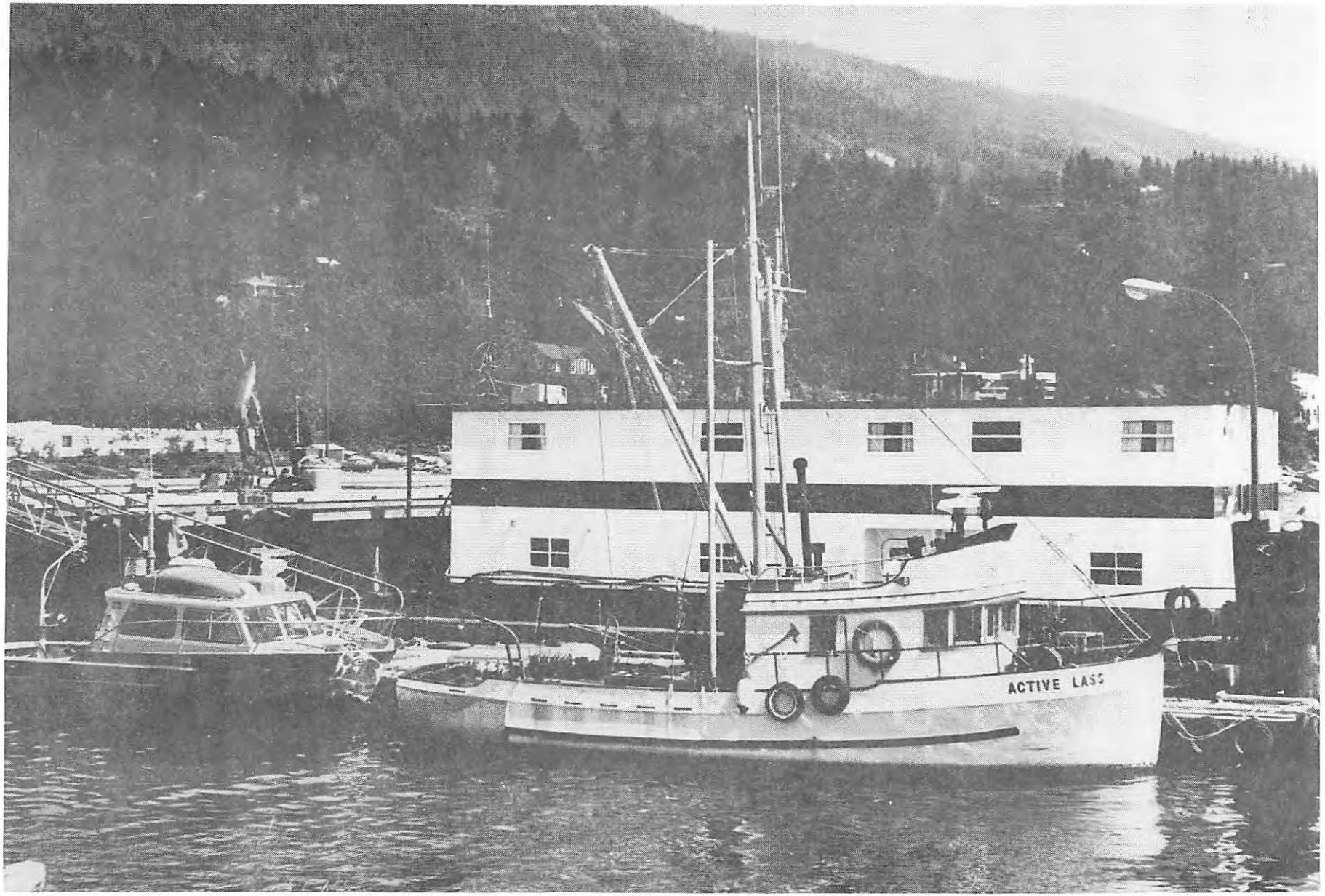


Areas of investigation by the Pacific Environment Institute in 1975



Vessels of the Pacific Environment Institute:
Rear - L.PACIFICA; Left Front - CHIMAERA IV; Right Front - ACTIVE LASS

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Restricted

This document may not be quoted as a scientific reference. Further information on programs of the Pacific Environment Institute may be obtained by correspondence with individual investigators or with:

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December 31, 1975

PACIFIC ENVIRONMENT INSTITUTE

West Vancouver, B.C.

SUMMARY REPORT 1975

Although 1975 was characterized by a state of flux associated with reorganization in the Fisheries and Marine Service, with a certain degree of uncertainty for programs, the Pacific Environment Institute (PEI) had a productive year. Much of the building activity and development of facilities that marked the first four years of the Institute's existence had been completed and the staff could concentrate on research and services. PEI continued a program in research and development related to water quality and habitat protection under Fisheries Management. The results of research have been published in the usual scientific and technical report media (see appended lists).

An effort continued toward applying new knowledge for improvement of the aquatic environment for fisheries habitats. A strong contribution was made by PEI staff during 1975 in this respect toward the preparation of a DOE Brief Presented to the Pollution Control Board Inquiry into the Pollution Control Objectives for the Forest Products Industry of British Columbia, coordinated by the Environmental Protection Service, Vancouver. Ecological and oceanographic findings in the vicinity of Port Mellon in Howe Sound were translated for the Environmental Protection Service and the B.C. Pollution Control Branch into requirements for protection of the aquatic ecosystem in design of a new outfall for effluent disposal from the pulp mill at Port Mellon. Advice was provided to the pulp and paper industry on reduction of toxicity of its water-borne effluents.

Ecological studies of PEI staff on the Fraser River delta continued to make a major input into recommendations of the Ecological Subcommittee of the Airport Planning Committee, concerning extension of runways onto the delta for the Vancouver International Airport. On the Fraser River delta also, an investigation was conducted in cooperation with B.C. Hydro on the effect of hydraulic ditching for burying power cables. The objective was to determine the rate of recolonization following such a disruption and the duration of ecological set-back. On a smaller scale for a more localized situation, PEI ecologists made a contribution to the DOE report, "An Ecological Assessment of the Seymour-Maplewood Foreshore Area", which concerned itself with the ecological impact of proposed developments on the Maplewood tide flats, on the north shore of Burrard Inlet east of the Second Narrows. A research program was developed to determine the ecological effects of ocean dumping, especially on the Point Grey dump site, in support of new federal legislation, the Ocean Dumping Control Act.

A review was completed for the NRC Associate Committee on Scientific Criteria for Environmental Quality on "Waterborne dissolved oxygen requirements and criteria with particular emphasis on the Canadian environment".

This has received considerable attention, particularly from the International Joint Commission with respect to water quality in the Great Lakes. Summaries and bibliographies of environmental knowledge for 18 critical estuaries in British Columbia were continued for the Estuary Working Group of the Regional Board Pacific Region. Reports were printed on the Squamish and Skeena River estuaries, with a draft completed for review on the Cowichan-Chemainus River estuaries.

On the international front, the Program Head continued as chairman of the Intergovernmental Oceanographic Commission's International Coordination Group on the Global Investigation of Pollution in the Marine Environment (GIPME), with the third session held in UNESCO, Paris, during 28 May - 4 June 1975, where a Comprehensive Plan for GIPME was completed. He also continued as chairman of the GESAMP Working Group on Principles for Developing Coastal Water Quality Criteria, with the Second Session held in Dubrovnik, Yugoslavia, 20-25 October 1975. He presented an overview on Marine Pollution to the United Nations Environment Programme Level One Advisory Group Meeting in Nairobi, Kenya, 10-14 November 1975. The Deputy Program Head continued to provide oceanographic input to the International North Pacific Fisheries Commission (INPFC), with a report on Canadian Oceanographic Research in the Subarctic Pacific Region submitted to the 22nd Annual Meeting of INPFC.

In the TOLERANCE BIOLOGY section, research was continued on characterizing and evaluating the effects of pollutants on salmonids. The floating laboratory L. PACIFICA was anchored near the Port Alice sulphite pulp mill in Neroutsos Inlet during July and August. Unfortunately the pulp mill closed down two weeks before the field program commenced, because of a labour strike. However, it was decided to modify the program and take advantage of the improved conditions in the inlet, with no effluent entering, for future comparison with heavily polluted conditions. A marked improvement in water quality (dissolved oxygen, transparency and colour) was evident in comparison to conditions in the past with the mill operating. No significant influence of inlet water, pumped aboard from various depths, on swimming stamina or on residual oxygen bioassay results with chum salmon underyearlings (*Oncorhynchus keta*) was noted, when compared with controls. This suggested that toxic components and low-oxygen effects of the spent sulphite liquor were absent during the study period.

Laboratory studies in Tolerance Biology have maintained emphasis on oxygen uptake and swimming stamina with Pacific salmon exposed to kraft-mill effluent in a tunnel-type respirometer. A heated seawater system is being developed for culture of invertebrates, especially for oyster larvae (*Crassostrea gigas*), which will allow extension of bioassays to important food chain organisms. Hopefully, these invertebrate bioassays will identify sensitive species suitable for monitoring and for assessing the hazards of marine waste discharges.

A UBC graduate student under our direction in Tolerance Biology is investigating the osmoregulatory capability of migrating salmonids exposed to isolated kraft pulp-mill effluent (KME) components, an important problem in estuaries. A toxic stress from a pollutant coupled with a salinity stress and need for osmo-adaptation could prove particularly critical to migrating salmonids. It has been noted so far that dehydroabietic acid is more toxic to

sockeye salmon (*Oncorhynchus nerka*) in fresh water than in sea water, but the unsaponafiable neutrals extracted from kraft mill effluent are more toxic in sea water.

Behavioural studies on effects of kraft mill effluents on salmonids have continued. Chum fingerlings (*O. keta*) in sea water showed a marked avoidance (76% of test time in clean water) to 19% full effluent. However, in 11% and 8% effluent chum showed no avoidance response. Sea water-adapted juvenile coho showed a marked preference for 15% effluent (30% of test time in clean water), but less preference for 8% effluent (44% of time in clean water). It was planned to investigate the possible effects of salinity, pH and effluent colour on the avoidance response. Development of electrophysiological facilities and techniques continues for future studies to be coupled with behaviour.

The ECOLOGY section maintained investigations on ecological changes in disrupted habitats and on effects of pollutants on primary production. Algal physiology studies were continued in the laboratory with axenic cultures of marine microalgae to examine the effects of certain natural and man-made environmental stresses on their viability and growth. Many species showed a remarkable capacity for surviving several months in total darkness. Exposure of phytoplankters to borate concentrations of 5-100 ppm B in continuous light showed that: (a) 10 ppm B was completely innocuous; (b) 50 ppm B caused partial inhibition of growth, which was generally overcome after adaptation; and (c) 100 ppm B was totally inhibitory to growth of about 35-40% of the species tested, but was tolerated by the remaining species often after gradual adaptation.

Phytoplankton ecological studies were continued in the field in freshwater and marine environments. In Howe Sound, the most productive regions (500-1500 mg C $m^{-2}day^{-1}$ during the growing season), were those removed from the direct influence of turbid Squamish River water and/or dark-coloured pulpmill effluent. Under the conditions where light penetration was inhibited, production ranged from 100 to 500 mg Cm^{-2} day^{-1} . Studies using axenic cultures of *Skeletonema costatum*, *Dunaliella tertiolecta* and *Amphidinium carteri* demonstrated some toxicity at high concentrations of KME (30-40%) in sea water, but a remarkable ability to adapt to concentrations higher than normally encountered *in situ*, given sufficient time, i.e. 20-30 days. Evidence from both field and laboratory studies in 1975 indicated that light attenuation by KME is a far more serious problem for phytoplankton than toxicity.

A UBC graduate student continued to study the production of benthic algae in the Squamish River estuary, with emphasis on energetic relationships between algae and the dominant invertebrates (amphipods) and rates of import-export of algae from caged areas. The highest export occurred during the November-January period. The heaviest utilization occurred in February and March, coincident with peak production of both algae and amphipods.

A study in Carnation Creek on Vancouver Island and an ongoing monitor program in Babine Lake comprised the freshwater effort of the plankton ecology group. It has been found that removal of the forest canopy, as noted in a clear-cut logged watershed (Ritherdon Creek) adjacent to Carnation Creek, did not result in a significant increase in production. The average standing

crop of chlorophyll *a* in both Carnation and Ritherdon Creeks during 1974-75 was among the lowest ever recorded in the literature for any area in the world.

As part of an ongoing lake-monitor program, production, chlorophyll *a*, light and temperature studies were carried out in Babine Lake during May-June 1975. Results showed no significant increases in productivity above 1973 levels, and copper concentrations in the water at two locations adjacent to the mine tailings pond appeared to be low enough so as not to inhibit phytoplankton growth at that time.

Benthic ecological studies concentrated on the Squamish and Fraser River estuaries, although a number of other areas along the B.C. coast were investigated. Observed penetration of the salt wedge up the Squamish River and through the culverts in the dyke along the east bank of the river suggests that the culverts, installed at considerable expense in 1972, are not allowing as much fresh water into the central delta as originally hoped. Although some new species have colonized the habitats behind the river dyke, the species composition of the amphipods remained unchanged. *Gammarus setosus*, a slightly more stenohaline amphipod than *Anisogammarus confervicolus*, has not moved into the central basin from the Mamquam delta habitats 1 km away.

A study by a UBC graduate student on the energetics and population ecology of barnacles (*Balanus glandula*) in Howe Sound has shown initially that barnacles transplanted near the Port Mellon pulp mill survived for 4 months, but all died following start-up of the mill after a prolonged shut-down. Barnacles transplanted to the central sectors of the Squamish estuary suffered high mortality during the high summer runoff period, but the mortality decreased during low river runoff in autumn.

Studies were continued on Sturgeon Bank in the vicinity of the Iona Sewage Treatment Plant outfall during early 1975 by a German exchange scientist. A considerable impact of sewage effluent on benthos has led to a degraded zone adjacent to the outfall. Mud flat communities in the upper intertidal zone were less affected than the sand flat assemblages. The highest biomass on Sturgeon Bank (ave. 35g wet wt m^{-2}) was noted in the finer sediments adjacent to emergent vegetation. Similar or even higher biomass was found in eel grass (*Zostera marina*) beds in the low intertidal zone on southern Roberts Bank. Jetties and causeways deflect fresh water from parts of the delta, and this influences the patterns of distribution of the biota.

A study was initiated on Roberts Bank to document the speed and pattern of re-establishment of benthic communities following disruption by hydraulic ditching to bury B.C. Hydro power lines leading to Vancouver Island. Communities along the power line route are dominated by amphipods (*Corophium insidiosum*), sabellid polychaetes (*Manayunkia aestuarina*) and a tanaid (*Tanais* sp.).

The POLLUTANT CHEMISTRY section was involved in a number of projects on distribution, behaviour and effects of environmental contaminants. In the organic chemistry group, a joint study with the Cultus Lake Laboratory of the International Pacific Salmon Fisheries Commission on foams in aerated lagoons of interior British Columbia pulp mills was concluded with presentation of a paper at the 1975 Environment Improvement Conference of the Technical Section

of the Canadian Pulp and Paper Association in Vancouver, B.C. The foam collected in two aerated lagoons was found to be highly toxic to juvenile sockeye salmon. Chemical fractionation of one foam revealed large amounts of toxic resin acids and neutral diterpenes. In the other foam, toxicity was related to a pitch dispersant and unidentified substances. Neither foam could be readily detoxified by biological treatment in the laboratory.

Fish tainting studies on KME were continued. Fraser River eulachons were intercepted and exposed in the laboratory to three concentrations of biologically-treated whole effluent from the pulp mill at Kitimat. At concentrations as low as 8% KME, both flavour and odour of the exposed fish were rated low by a taste panel, whereas fish exposed to 0.8% KME were indistinguishable from controls. Volatile sulphur compounds were detected in the flesh of the exposed fish by gas chromatography, the measured levels increasing with degree of exposure.

Research continued on organochlorine compounds in bleach plant effluents. One compound (4,5,6 trichloroguaiacol), with an LC50 of 1.1 mg/l for juvenile sockeye salmon, was found at levels of 0.63 mg/l in samples of caustic extraction effluent from a coastal mill. This, along with other compounds, were detected in a fish-toxic sample of whole mill effluent after biological treatment in a 5-day aerated stabilization lagoon. Such observations give rise to concern as to how effectively these organochlorines are removed in conventional treatment systems.

The inorganic chemistry group was heavily committed to field programs in areas receiving mine tailings, i.e. Rupert Inlet, Howe Sound and Strait of Georgia (near Texada Island) during 1975. Analyses of the interstitial water in cores indicated that there is no discernable increase in copper, as a result of submerged mine tailings, compared to natural sediments.

Participation in the CEPEX program in Saanich Inlet permitted a study to be made on the uptake of copper by chum salmon in three full-sized plastic bags (30 m in height by 10 m in diameter, containing about 200 m.tons of water each), one dosed with 2.5 µg Cu/l while the other two were controls. There is no evidence so far of bioaccumulation of copper by chum salmon at this concentration.

In FISHERIES OCEANOGRAPHY, annual and year-to-year changes of oceanographic conditions in relation to fisheries were examined in the Subarctic Pacific in consultation to the International North Pacific Fisheries Commission. A second joint report, in collaboration with U.S. and Japanese scientists, entitled "Oceanography of the Subarctic Pacific Region, 1960-71", was completed, reviewed by national authorities, and is now in the hands of INPFC for publication as a bulletin.

Sea surface and subsurface temperatures were examined at Ocean Station P and along Line P for 1972 and 1973, and a report was submitted to the 22nd Annual Meeting of the INPFC. It was noted that at Station P, sea surface temperatures during January-April were slightly higher in 1973 than in 1972, but from April onward they were 1-2^{0}C higher in 1972 than in 1973. In the subsurface waters (100-125 m), generally the opposite trends to those in the surface waters prevailed.

A study of oceanographic conditions, based on past data, was commenced in Queen Charlotte Sound, Hecate Strait and Dixon Entrance. This work is of considerable interest in fisheries research and management, as well as essential background to investigation of possible future threats of oil pollution.

Past data acquired in MARINE POLLUTION studies are being utilized in preparation of reports for the Estuary Working Group of the DOE Regional Board Pacific Region on 18 estuaries in British Columbia, considered critical from the point of view of threat of developments and protection of living resources. Reports on the Fraser, Squamish and Skeena River estuaries have been completed.

Laboratory studies on diffusion of atmospheric oxygen into "still" sea water of homogeneous salinity with a positive vertical temperature gradient, showed comparatively rapid oxygenation of oxygen-stripped sea water, apparently by convective motions set up by lateral temperature gradients. However, when a layer of fresh water was placed on the sea water to develop vertical salinity stratification, oxygenation was greatly retarded.

More details on individual projects are given in the Investigators' Summaries.

Michael Waldichuk
Program Head

REGIONAL, NATIONAL AND INTERNATIONAL ACTIVITIES

Staff of the Pacific Environment Institute continued to participate to the extent that time and budget would allow, in various cooperative and consultative functions dealing with water quality and fisheries habitat protection at the regional, national and international levels. This sometimes involved cooperative research in both the laboratory and field, and at times in fora on joint consultation. Research scientists served on graduate committees and supervised research work of a number of graduate students from local universities, in addition to giving graduate courses while on leave. With new federal environmental legislation coming into force, e.g. the Ocean Dumping Control Act and the Environmental Contaminants Act, consideration was given to research and regulatory procedures for their administration. Several staff (Drs. Davis, Rogers, Levings and Waldichuk) contributed to the DOE Brief (coordinated by EPS) presented to the B.C. Pollution Control Board Inquiry into the Pollution Control Objectives for the Forest Products Industry of British Columbia. With an increasing amount of research contracted to the private sector, several scientists have been designated as scientific authorities on contracted projects and as liaison officers for CPAR (Cooperative Pollution Abatement Research) projects administered by the Canadian Forestry Service, Ottawa.

Dr. Waldichuk continued as a member of Environment Canada's Regional Board Pacific Region and of its Estuary Working Group, where he directed the work of preparing reports on 18 estuaries in British Columbia considered critical from the point of view of development and threat to their living resources. Reports on the status of environmental knowledge were issued on the Fraser River, Squamish River and Skeena River estuaries, and the report on the Cowichan and Chemainus River estuaries was well advanced by the end of 1975. Dr. Waldichuk continued to serve as a member of the Pacific Sub-Committee on Oceanography of the Canadian Committee on Oceanography (CCO), on the Board of Management of B.C. Research and the B.C. Research Council, and as a vice-president of the Vancouver Public Aquarium Association. He was a member of the Program Committee for the 13th Pacific Science Congress, and convened a symposium on Sub-lethal Effects of Pollution on Aquatic Organisms in the section *Aquatic Resources and their Management*. He was appointed a member of the Regional Ocean Dumping Advisory Committee (RODAC) to administer the Ocean Dumping Control Act. Nationally, Dr. Waldichuk served on the Canadian National Committee of the Pacific Science Association and on the Subcommittee on Water of the National Research Council Associate Committee on Scientific Criteria for Environmental Quality.

Internationally, Dr. Waldichuk continued to serve on the IMCO/FAO/Unesco/WMO/WHO/IAEA/UN Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), and on two of its working groups - (1) The Scientific Basis for Disposal of Waste into the Sea, and (2) Principles for Developing Coastal Water Quality Criteria - being Chairman of the latter and convening the Second Session in Dubrovnik, Yugoslavia, October 20-25, 1975. Dr. Waldichuk continued to serve as Chairman of the Intergovernmental Oceanographic Commission's International Coordination Group on the Global Investigation of Pollution in the Marine Environment which held its Third Session in

Unesco, Paris, during May 26 to June 4, 1975. He was also appointed member of the Scientific Advisory Committee on Physical and Chemical Aspects of the Dispersion of Natural and Artificial Substances and Heat in the Oceans and Seas of the International Association for the Physical Sciences of the Ocean. Dr. Waldichuk presented an Overview on Marine Pollution to the United Nations Environmental Programme's Level One Advisory Group Meeting in Nariobi, Kenya, November 10-14, 1975.

Mr. Dodimead continued to provide oceanographic advice to the Canadian delegation to the annual meeting of the International North Pacific Fisheries Commission. He served as Secretary of the Pacific Sub-Committee on Oceanography of CCO and Chairman of its Ships Schedule Panel. He was co-organizer and co-convenor of the symposium "Climatic Change in the Northeastern Pacific Ocean", jointly sponsored by the Pacific Science Association and the Eastern Pacific Oceanic Conference, at the 13th Pacific Science Congress, Vancouver, B.C., August 25, 1975. Mr. Dodimead continued to serve as alternate member on the DOE Regional Board Pacific Region and on the Pacific Sub-Committee on Oceanography of CCO.

Dr. Davis finalized his involvement with the Fisheries Management Project Team of the Fisheries and Marine Service, Pacific Region, in the cybernetics project, "Design of a Management Framework (MIDAS)". He assisted in organizing and convening the symposium on Sub-lethal Effects of Pollution on Aquatic Organisms at the 13th Pacific Science Congress, August 26-28, 1975. He was appointed liaison officer for the CPAR Research Project No. 448 conducted by B.C. Research. Dr. Davis was a member of a national working group, composed of staff from Environmental Protection Service, Fisheries Management of the DOE Fisheries and Marine Service and the Ontario Ministry of Environment, studying the usefulness and methodology for standardizing fish toxicity tests with reference toxicants. He was an adviser to the International Joint Commission on dissolved oxygen criteria for use in the Great Lakes region. Dr. Davis continued to serve on a Sub-Committee of the Water Pollution Control Federation on revision of the U.S. document "STANDARD METHODS for the Examination of Water and Wastewater". He organized and presented an intensive 3-unit course (Biology 615) at Concordia University, Montreal, P.Q., while on leave during December 5-12, 1975.

Dr. Rogers continued collaborative research on toxic effects of pulpmill effluents in river systems of British Columbia with the Cultus Lake Laboratory of the International Pacific Salmon Fisheries Commission. He participated in a round-robin exchange of samples for resin acid analysis with Domtar Research Laboratory, Senneville, P.Q., and Dr. M. Fox, CCIW, Burlington, Ont. He was a liaison officer on CPAR Project No. 360 to Econotech Services Ltd. on "Identification and determination of the toxicity contribution of the toxic materials in each kraft and sulphite process effluent prepared in a pilot plant". Dr. Rogers continued serving on a committee steering research on oil contaminants in fish flesh at the Vancouver Fisheries Research Laboratory. He was a member of the Federal/Provincial Task Force on Pollution in the Thompson River.

Dr. Thompson was chairman of the Marine Chemistry Panel of the Pacific Sub-Committee on Oceanography of CCO. He served as a member of the

Capilano College advisory board, appointed to establish criteria for a planned chemical technology program. Dr. Thompson was involved in development of an application form for permit issuance under the new Ocean Dumping Control Act.

Dr. Stockner continued as chairman of the Babine Lake Sub-Committee on Monitoring and as a member of the Babine Lake Steering Committee, Carnation Creek Watershed Steering Committee, Thompson River Federal/Provincial Task Force on Pollution and of the OECD Lake Monitoring Committee. He served as the liaison officer for CPAR Project No. 461 conducted by Dobrocky Seatech. He attended the Congress of the Limnological Society of South Africa in Salisbury, Rhodesia, September 9-13, 1975, where he delivered two papers and chaired a technical session.

Dr. Levings continued a research program on the effects of sewage effluent in the Fraser River estuary in collaboration with Mr. G. Otte of Hamburg, FRG, under the Germany/Canada Science Technology Exchange Agreement. He also developed a cooperative project with the B.C. Hydro and Power Authority on the ecological effect and re-establishment of benthic communities after burying a power cable across Roberts Bank. Dr. Levings attended the NATO/CCMS Coastal Pollution Workshop as one of the Canadian delegation in Ostend, Belgium, June 9-14, 1975, where he delivered a paper and participated in workshop discussions. He taught a course in Marine Biology at the Bamfield Marine Station while on leave during July 1975, and was appointed an honorary lecturer at the University of British Columbia. Dr. Levings was involved as a scientific authority in supervising three research contracts, related to effects of dumping on benthic communities, in conjunction with the Ocean Dumping Control Act. He was appointed a member of the Technical Sub-Committee of the Regional Ocean Dumping Advisory Committee.

Dr. Greer was actively involved in organizing and editing of the papers for the symposium, "Chemistry and Physics of Aqueous Gas Solutions", sponsored by the Electrothermics and Metallurgy and the Industrial Electrolytic Divisions of the Electrochemical Society, Inc., at its 147th Meeting held in Toronto, Ont., May 12-16, 1975.

Staff of the Pacific Environment Institute participated extensively in various public relations ventures, such as talking to university students, high school classes and church groups and providing interviews on radio and television. The work of the Pacific Environment Institute was featured in a one-half hour program on the "Bob Switzer Show", CBC-TV Vancouver, on May 14, 1975. Staff were involved in filming by the CBC national network on June 24-25, 1975 for the program series "New Wave", and by local staff for a further CBC-TV show on the Bob Switzer program.

SITE AND FACILITIES DEVELOPMENT AND AQUARIUM OPERATION

All buildings, trailers, vessels and other facilities were generally in place and performing quite adequately, except for one or two items, for the research needs of the Pacific Environment Institute and of other associated groups on the site.

The "Aquarium", one of the remaining buildings of the Great Northern Cannery demolished in late 1968, and serving for the indoor fish-holding facilities, was beginning to show the need for replacement. Some thought was given to planning for replacement of this building and improvement of the total water and fish-holding facilities in an integrated system in the long-term plan for permanent buildings.

Preliminary discussions were held with municipal officials and the mayor of West Vancouver concerning installation early in 1976 of nine trailer units to be complexed into a new laboratory and office unit of 6,500 sq.ft. by the Environmental Protection Service on the section of the site north of Marine Drive in the old "gravel pit".

1. Water Systems

The seawater system continued functioning with occasional maintenance, but was expected to require renovation in due course to eliminate apparent leaks in the intake lines that cause pump priming problems during switch-over from one pump to another. The two wells continued to supply most of the freshwater needs for fish-holding and experimental work, but water utilization was approaching, at times, the maximum capacity of the wells. It was planned to eventually install a new well at the Cypress Creek property, in order to augment the existing freshwater supply. The water from Cypress Creek was still not flowing properly under flood conditions of the creek, and a new modification for the creek intake system to eliminate clogging by silt and sand was being considered.

2. Sewage and Laboratory Waste Disposal

A Working Group on Waste Removal at PEI continued to consider special problems of laboratory wastes generated on the site. Solvents were disposed of through the incinerator facilities of the University of British Columbia. Staff cooperated with B.H. Levelton and Associates, contracted by the Environmental Protection Service, in a study of PEI laboratory waste disposal problems, among others, and in preparation of a report on DOE Laboratory Waste Assessment Study in the Pacific Region.

Existing facilities for sewage and waste disposal at PEI, installed during 1970, consist of a septic tank for sanitary sewage and an acid-neutralizing pit for laboratory waste, all draining into an extensive tile field under the grassed-in grounds in front of the main trailer complex. With installation of municipal trunk sewers in West Vancouver, it will be essential to connect the sanitary sewerage and laboratory waste systems of the Pacific Environment Institute into the municipal system sometime in 1976.

3. Vessels

The research barge, L. PACIFICA, had a seawater recirculation system installed early in 1975 to bring it up to the standard required for field work by the Tolerance Biology section. The ex-troller, ACTIVE LASS, continued to perform outstandingly as a day vessel for field work in Howe Sound, Burrard Inlet and Indian Arm. The Pacific Environment Institute continued to use, for field programs of longer duration than a day or two, the larger vessels, such as CSS LAYMORE and CSS VECTOR, in the Pacific Coast Ships Pool scheduled by the Ships Schedule Panel of the Pacific Sub-Committee on Oceanography of CCO.

In 1975 PEI commissioned a new support vessel, the CHIMAERA IV. She was designed to act as a modertately fast, efficient sampling vessel for all sea-going projects and to work in support of programs based on L. PACIFICA, including assisting in anchoring that laboratory vessel. CHIMAERA IV is 32 feet overall length, 11 feet in beam and has a semi-displacement type hull. She is built of marine grade aluminum and powered by a single, high speed, Caterpiller marine diesel engine. The hull is foamed internally to reduce noise and condensation. The design provides a large flat working deck aft, a hydraulic davit-mounted winch for oceanographic work, a tank with pump for live specimens, a well forward of the transom for working close to the water and comprehensive electronic instrumentation. This vessel has proven excellent for her sampling and support tasks and has made a successful trip offshore down the west coast of Vancouver Island.

4. Aquarium Operation

With the new Aquarium Manager joining the staff of PEI in 1974, opportunity was afforded to make an inventory of stocks, to review all fish-holding facilities and operations, and to institute new techniques for improved service and efficiency.

A consolidation of the previous year's inventory was undertaken in order to provide sufficient holding space. Surplus stocks were disposed of and diseased fish were destroyed. Important holdover stocks of salmonids included 2000 second-year sockeye salmon in fresh water; 5000 second-year steelhead trout in fresh water, 2000 third-year steelhead trout in fresh water, 50 fourth-year steelhead trout in salt water, 3000 second-year coho in fresh water and 500 second-year coho in salt water. Other stocks kept on site for the Vancouver Laboratory included coho salmon, chinook salmon, pink salmon, rainbow trout, steelhead trout, Pacific herring and halibut.

The new 1974-75 PEI stocks were obtained as fertilized eggs, and included 5000 chum salmon from Incher Creek as well as 8000 sockeye salmon from Cultus Lake. Approximately 10,000 rainbow trout eggs, obtained from the Abbotsford Hatchery in spring, were hatched in cooperation with the EPS bio-assay laboratory. Later, in October, another batch of 10,000 Abbotsford Hatchery fry was obtained for EPS when the spring-hatched fish became too large for their operation. The combined coho salmon requirement for PEI, EPS and the Vancouver Laboratory was met with a stock of 19,000 fish held on the site.

In order to fulfill a request for stocks of two rockfish species, field trips were undertaken with an improved fish transport system to gather the specimens. A five-day expedition to Port Hardy in June resulted in the capture of numerous sub-adult sablefish, black rockfish and yellowtail rockfish. The fish were all taken with hook and line. Approximately 90 yellowtail rockfish were transported back to PEI and were successfully held on site. A second two-day trip for the purpose of collecting black rockfish "young of the year" was undertaken in July. A 1500-fish sample was seined and then transported to PEI where it was successfully maintained. Oregon moist pellet was readily accepted by these non-salmonids and a growth-curve study was made.

Within the framework of the existing aquarium building, an area-by-area renovation was instigated. A small workshop for specialized aquarium-related jobs was created. Equipment for a small disease diagnostic centre was ordered and received. Conversion of a small room adjacent to the food preparation facilities for the centre was commenced. When finished, the diagnostic centre will afford PEI and other on-site groups basic disease diagnostic capabilities.

A hatchery room has been constructed, and hatching facilities are just being completed. Four pairs of six-foot troughs will operate on independent water supplies, which should allow for experimental capability, if scientific investigation demands it, as well as for general stock hatching duty. A system of upwelling,recirculated water utilizing entirely plastic and fibreglass fittings has been put together for this experimental hatchery. Preliminary plans have also been drawn up for a display area adjacent to the hatchery. In preparation for several large diet experiments, the Vancouver Laboratory group has closed in their section with a walk and two doors. The inside of the aquarium building is being painted, one section at a time, as storage areas for aquarium equipment are put together and other improvements are made. In an effort to remove excess weight, as a safety measure, the upper "loft" is being phased out as a storage area, wherever possible, and useful equipment is consolidated elsewhere.

Improvements to the outside of the aquarium facility included installation of aluminum non-skid tracking along the main east-west walkway, creation of a new stair and ramp unit at the west end of the deck, and addition of nets and brushes for most tanks and racks for maintenance equipment. An in-depth study of the various water systems and distribution lines has been made in conjunction with all Aquarium users. Several innovations, including a power brush for cleaning tanks, a standpipe removal tool and an automatic flushing valve have been designed and fabricated for use, with considerable saving of time and effort over previous manual methods. A manuscript describing the power brush has been completed.

In order to help alleviate a perceived lack of interpretive material about local marine fishes, a series of articles, primarily aimed at the general public and sport fishermen, has been undertaken in the magazine "Western Angling". A second, intermittent series in "Pacific Diver", involving marine fishes of interest to SCUBA divers, has also begun.

STAFF LIST

CONTINUING FULL TIME

Name	Responsibility
ADMINISTRATION AND SUPPORT SERVICES	
MANAGEMENT AND ADMINISTRATIVE SERVICES	
M. Waldichuk, Ph.D.	Program Head
A.J. Dodimead, M.Sc.	Deputy Program Head
L.P. Beck, (Ms.)	Secretary
D.I. Price (Mrs.)	Stenographer/Receptionist
BUILDINGS, GROUNDS, FACILITIES AND VESSELS	
C.K. Collinson	Buildings, Grounds and Vessels Supervisor
G.A. Grant	Carpentry/Electrical
R.W. Matheson	Vessel Master
FISH CULTURE	
A.O. Lamb, B.Sc.	Aquarium Manager
R.C.T. Corrigan (to Aug.31, 1975)	Aquarium Helper
J.B.E Heading	Aquarium Helper
RESEARCH PROGRAMS	
TOLERANCE BIOLOGY	
J.C. Davis, Ph.D.	Section Head and Research in Fish Physiology
G.L. Greer, Ph.D.	Neurophysiology-Behaviour
B.J. Mason (Ms.)B.Sc.(to Feb.15,1975)	Bioassay/technical support
I.G. Shand, B.Sc.	Bioassay/technical support
G. Kosakoski, B.Sc.(from May 20,1975)	Neurophysiology-Behaviour/technical support
ECOLOGY	
J.G. Stockner, Ph.D.	Phytoplankton Ecology
C.D. Levings, Ph.D.	Benthic Ecology
N.J. Antia, Ph.D.	Phytoplankton Physiology
D.D. Cliff, M.Sc.	Phytoplankton Ecology/biological support
N.G. McDaniel, B.Sc.	Benthic Ecology/technical support

Name	Responsibility
POLLUTANT CHEMISTRY	
I.H. Rogers, Ph.D.	Section Head and Research in Organic Chemistry
J.A.J. Thompson, Ph.D.	Inorganic Chemistry
A.E. Werner	Waterborne Wood Solids Research
H.W. Mahood	Organic Chemistry/technical support
D.W. Paton, B.Sc.	Inorganic Chemistry/technical support
FISHERIES OCEANOGRAPHY AND MARINE POLLUTION	
A.J. Dodimead, M.Sc.	Section Head and Research in Fisheries Oceanography
M. Waldichuk, Ph.D.	Marine Pollution
H.G. Christie, B.Sc.	Technical Support

TERM/CASUAL

F.P. Keough (Mrs.) (part time)	Library/Clerical
P. Edgell (from October 1,1975)	Aquarium Helper

VISITING SCIENTIST

	Project
G. Otte (to Feb. 15, 1975), Institut für Hydrobiologie und Fischereiwissenschaft, University of Hamburg, FRG. Visiting under Germany/Canada Science Technology Agreement (Collaboration with Dr. C.D. Levings)	Distribution of Macroinvertebrate Communities on a Mud Flat Influenced by Sewage, Fraser River Estuary, British Columbia

CONTRACT RESEARCH

Name	Supervisor	Project
R. Armour, B.Sc.	Dr. C.D. Levings	Roberts Bank Recolonization Study (supported in part by B.C. Hydro and Power Authority).

CONTRACT RESEARCH (cont'd.)

Name	Supervisor	Project
Leonard M. Bell, P.Eng., M.Sc.	Dr. M. Waldichuk	Inventory of information on British Columbia estuaries (funded through Estuary Working Group of DOE)
Douglas Buchanan, B.Sc.	Dr. J.G. Stockner	Collation of data from Howe Sound studies
Anne Costella, B.Sc.	Dr. J.G. Stockner	Axenic culture studies of KME toxicity to marine phytoplankton (funded by EPS)
Lindsay M. Hoos, M.Sc.	Dr. M. Waldichuk	Inventory of information on British Columbia estuaries (funded through Estuary Working Group of DOE)
Ronald J. Kallman, B.Sc.	Dr. M. Waldichuk	Inventory of information on British Columbia estuaries (funded through Estuary Working Group of DOE)

GRADUATE STUDENTS

Name	Supervisors	Thesis Topic
Sharon Brown, M.Sc.	Dr. Hagmier, U. of Victoria, and Dr. J.G. Stockner, PEI	Paleolimnology of Vancouver Island Lakes (Ph.D.)
Penelope Brown, B.Sc.	Dr. T.R. Parsons, UBC	The effect of simulated upwelling on the maximization of production in marine food chains (Ph.D.)
Douglas Buchanan, B.Sc.	Prof. T.R. Parsons, UBC, and Dr. J.G. Stockner, PEI	Mathematical model of the seasonal formation of organic matter in Howe Sound (M.Sc.)

GRADUATE STUDENTS (cont'd.)

Name	Supervisors	Thesis Topic
Kenneth Chan, M.Sc.	Prof.W.S. Hoar, UBC and Dr.J.A.J. Thompson, PEI	Sublethal effects of methyl-mercuric chloride on the reproduction of the fish, *Oryzias latipes* (Ph.D.)
H.Graham Christie,B.Sc.	Prof.C.Krebs, UBC, and Dr. C.D. Levings, PEI	Ecology of deep sublittoral benthos in Howe Sound (M.Sc.)
Gordon Ennis, B.Sc.	Prof.T.G.Northcote, UBC, and Dr.J.G.Stockner, PEI	Attached algal ecology of Kootenay Lake (M.Sc.)
Ronald Kistritz,B.Sc.	Prof.T.G.Northcote, UBC, and Dr.J.G.Stockner, PEI	The fate of macrophyte production (M.Sc.)
George T. Kruzynski,M.Sc.	Prof.D.J.Randall, UBC and Dr. J.C.Davis, PEI	Acute and sublethal physiological and behavioural response of salmonids to isolated toxic components of kraft pulpmill effluent (Ph.D.)
Raymond Lauzier,B.Sc.	Dr. G.H. Geen, SFU and Dr. C.D. Levings, PEI	Mercury uptake in a benthic food chain (M.Sc.)
David Levy, B.Sc.	Prof. D.McPhail, UBC, and Dr. C.D. Levings, PEI	Feeding ecology of juvenile chinook salmon (*Oncorhynchus tshawytscha*) at the Squamish estuary (M.Sc.)
Ross Murray, B.Sc.	Dr. G.H. Geen and Dr. L. Druehl, SFU, and Dr. J.G. Stockner, PEI	Sinking rates of marine phytoplankton (M.Sc.)
W.Martin Pomeroy, M.Sc.	Prof.J. Stein, UBC, and Dr.J.G.Stockner and Dr. C.D. Levings, PEI	Benthic algae bioenergetics at the Squamish River estuary (Ph.D.)
R. Prange, B.Sc.	Prof. J. Stein, UBC,and Dr. C.D. Levings, PEI	An autecological study of *Blidingia minima* var. *subsala* (Chlorophyceae; Ulvales) at the Squamish delta (M.Sc.)
Paul Rankin, B.Sc.	Prof.T.G.Northcote, UBC, and Dr.J.G.Stockner, PEI	Zooplankton ecology of Babine Lake (M.Sc.)
R.S.S. Wu, B.Sc.	Dr. D.J.Randall,UBC, and Dr. C.D.Levings, PEI	Ecology and bioenergetics of barnacles (*Balanus glandula*) in Howe Sound (Ph.D.)

PUBLICATIONS AND REPORTS

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*Antia, N.J. 1975. Review of: "Algal Physiology and Biochemistry (Botanical Monographs, Vol.10)." Edited by W.D.P. Stewart, University of California Press, Berkeley and Los Angeles, 1974, ix + 989 p. J. Fish. Res. Board Can., 32: 1500-1501.

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Davis, J.C. 1975. Important considerations in toxicity bioassays with fish and other aquatic life. Presented at Ontario Ministry of Environment, Toxicity Workshop, Nov. 4 and 5, 1975, Toronto (to be published in Symposium Edition by Ontario Ministry of Environment for circulation to participants).

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Davis, J.C. 1975. Guide to the use of the floating laboratory vessel, L. PACIFICA. Pacific Environment Institute internal report for scientific users of vessel, 12 p.

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Greer, G.L., and A. Lamb. 1975. Pacific Environment Institute Aquarium Facility Report No. 1. October 1974 - March 1975. 38 p.

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SCIENTIFIC PAPERS, GENERAL TALKS, LECTURES AND SEMINARS GIVEN BY PACIFIC ENVIRONMENT INSTITUTE STAFF

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Davis, J.C. The exchange of oxygen at the gills of fish in response to oxygen availability. Chemistry and Physics of Aqueous Gas Solutions Symposium, 147th Meeting of the Electrochemical Society, Inc., Toronto, Ont., May 12-16, 1975.

Davis, J.C. Progress in sublethal effect studies with kraft pulp mill effluent and salmonids. Aquatic Resources and their Management. 13th Pacific Science Congress, Vancouver, August 26, 1975.

Davis, J.C. Work in progress to determine the effects of bleached kraft mill effluent on Pacific salmon. National Council for Air and Stream Improvement, West Coast Regional Meeting, Boise, Idaho, October 23, 1975.

Davis, J.C. Important considerations in toxicity bioassays with fish and other aquatic life. Ontario Ministry of Environment, Toxicity Workshop, Toronto, Ontario, November 4, 1975.

Davis, J.C. Panelist in discussion of the usefulness and applicability of reference toxicants for standardizing toxicity bioassays. Ontario Ministry of Environment, Toxicity Workshop, Toronto, Ontario, Nov. 4, 1975.

Davis, J.C. Water Pollution Studies. Biology 615. A 3-unit graduate course attended by graduate students from 3 universities, university faculty, Environment Canada personnel and staff from the Pulp and Paper Research Institute of Canada. Department of Biological Science, Concordia University (Sir George Williams Campus), Montreal, Quebec, December 5-12, 1975.
(This course was taught, with 30 hours of lectures given, by Dr. Davis during his annual vacation leave.)

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Levings, C.D. Ecology of continental shelf benthos. Lecture to UBC graduate students in Biological Oceanography. Vancouver, B.C., January 16, 1975.

Levings, C.D. Effects of jetties and causeways on mudflat communities at the Fraser River estuary. Talk at annual meeting of Pacific Northwest Oceanographers, Parksville, B.C., March 1, 1975.

Levings, C.D. Environmental science at the Pacific Environment Institute. Talk to students of Cleveland Elementary School, Pacific Environment Institute, West Vancouver, B.C., March 3, 1975.

Levings, C.D. Industrial disruption and ecology of beaches in Howe Sound. Talk to Gambier Island Community Association, North Vancouver, B.C., March 7, 1975.

Levings, C.D. Trophodynamics of benthic ecosystems. Lecture to UBC graduate students in biological oceanography. Vancouver, B.C., March 27, 1975.

Levings, C.D. Ecology of Howe Sound beaches. Talk to members of West Point Grey Presbyterian Church, Vancouver, B.C., April 21, 1975.

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Levings, C.D. Ecological studies at the disrupted Squamish estuary. Seminar at Bamfield Marine Station, Bamfield, B.C., July 9, 1975.

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Stockner, J.G. Howe Sound Under Stress. Gambier Island Ratepayers Association, Gambier Island, B.C., March 7, 1975.

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Thompson, J.A.J. Copper in marine waters - effects of mining wastes. Presented at the International Conference on Heavy Metals in the Environment, Toronto, Ont., October 27-31, 1975.

Thompson, J.A.J. Aspects of pollution chemistry. Lecture to class of second-year students in the B.C. Institute of Technology Pollution Option, BCIT, Burnaby, B.C., November 12, 1975.

Waldichuk, M. Relationship of Canadian marine pollution control legislation to international conventions. Seminar on Marine Pollution, Institute of International Relations, UBC, Vancouver, B.C., January 25, 1975.

Waldichuk, M. Some environmental problems in the Pacific Region. Council of Women, West Vancouver United Church, West Vancouver, B.C., February 24, 1975.

Waldichuk, M. The program of the Pacific Environment Institute. Talk and tour of facilities in PEI for the Volunteer Docents of the Vancouver Public Aquarium, March 8, 1975.

Waldichuk, M. Some water pollution studies at the Pacific Environment Institute. British Columbia Water and Waste Association, Engineers Club, Vancouver, B.C., March 12, 1975.

Waldichuk, M. The Pacific Environment Institute. A one-half hour program on CBUT (CBC-TV Vancouver) with host Bob Switzer, May 14, 1975.

Waldichuk, M. Activities of the Pacific Environment Institute. Talk and tour of PEI facilities for 17 Fisheries and Conservation Officers, coordinated by Mr. George Barber, Fisheries Operations, Pacific Region, June 14, 1975.

Waldichuk, M. The responsibility and work of the Pacific Environment Institute. Talk and tour of PEI facilities for scientists from the Ocean Research Institute, University of Tokyo, visiting with the research ship, R.V. HAKUHO-MARU, July 27, 1975.

Waldichuk, M. Research program of the Pacific Environment Institute. Talk and tour of PEI facilities for group of scientists attending the 13th Pacific Science Congress, August 24, 1975.

Waldichuk, M. Diffusion of oxygen into still sea water. 1975 IEEE Conference on Engineering in the Ocean Environment and the Eleventh Annual Meeting of the Marine Technology Society, San Diego, California, September 22-25, 1975.

INVESTIGATORS' SUMMARIES

INVESTIGATORS' SUMMARIES

A. TOLERANCE BIOLOGY

The Tolerance Biology Section continued to concentrate on characterizing and describing the effects of pollutants on salmonid fish in 1975. A literature review of oxygen tolerance levels of Canadian aquatic life which proposes water quality criteria for freshwater and seawater fish species, was published. Laboratory experiments were continued on acute and sublethal toxicity of pollutants to aquatic organisms, particularly salmonids. Existing techniques of bioassay were evaluated and facilities were developed for invertebrate larval bioassays. Studies were continued in the field particularly with the bioassay-equipped laboratory vessel, L. PACIFICA. Behavioural studies on salmonids exposed to pulpmill effluents and other effects were continued.

1. Acute Toxicity and Sub-lethal Bioassay Studies

J. C. Davis
I. G. Shand
B. J. Mason

(a) Laboratory Research

In the laboratory, work proceeded on acute toxicity bioassay methodology. In particular, the "residual oxygen bioassay" was evaluated. This procedure tests the O_2 extraction ability of fish in closed containers in the presence of a toxicant. The procedure was evaluated with regard to its usefulness, practicality, effect of fish acclimation to the test container, fish loading density influences, use of varying fish numbers and influence of initial oxygen tension in the water on results. This study indicated that the procedure is a rapid, sensitive method free from the above complications, with the exception of initial oxygen level in the test container. If the initial O_2 level is below about 40% of maximal O_2 saturation, results may be affected. Thus, difficulties may be experienced in applying the test to samples initially low in oxygen.

On-going activities in the laboratory included a study of oxygen uptake and swimming stamina with Pacific salmon exposed to kraft pulp mill waste in a tunnel-type respirometer unit. In addition, a heated seawater system and invertebrate culture area is under construction for toxicity studies with major species of invertebrates important to marine food chains. It is hoped that these studies will identify sensitive marine invertebrates that can be used for monitoring purposes and for assessing the hazards of marine waste discharges. It is proposed that euphausids, copepods, Pacific oyster larvae (*Crassostrea gigas*), butterclam larvae (*Saxidomus giganteus*) and mussel larvae (*Mytilus edulis*) be examined in this program. Results of invertebrate toxicity tests will be related to toxicity to salmonids so that relative species sensitivity can be ascertained.

(b) Field Studies

Our floating laboratory vessel, L. PACIFICA, was anchored near a coastal sulphite pulp mill at Port Alice, B.C. during July and August. The objective of this study was to examine acute and sublethal effects of low dissolved O_2 and sulphite waste on chum salmon underyearlings exposed to water pumped aboard from various depths. Fish stocks were held aboard in filtered, temperature-controlled, recirculated sea water which also served as "control" water for experimental purposes. Experiments consisted of swimming stamina tests, residual oxygen acute toxicity bioassays, avoidance behaviour and an oceanographic survey of Quatsino Sound and Neroutsos Inlet.

Two weeks prior to the field study, the pulp mill at Port Alice closed owing to labour difficulties and remained shut for the duration of the study. A marked improvement in water quality (dissolved O_2, transparency and colour) was evident in comparison to conditions in the past with the mill operating. Analysis of results failed to show any significant influence of inlet water on swimming stamina or residual O_2 bioassay results in comparison to controls, suggesting the toxic components of the effluent and low O_2 effects were absent during the study period. These data are considered highly useful "baseline" parameters for assessing the impact of the mill on receiving waters in future, and for studying the effectiveness of proposed in-plant control measures.

2. Behavioural Studies

G. L. Greer
G. Kosakoski

Work continued with laboratory avoidance studies of Pacific salmonids to kraft mill effluent. Chum fingerlings showed a marked avoidance (76% of test time spent in clean water) to 19% full effluent [*ca.* 0.25 toxic units (TU), where TU = % effluent/96 hr LC50] but no avoidance to 11% and 8% effluent (0.12 and 0.09 TU, respectively). Saltwater adapted juvenile coho showed a marked preference for 15% effluent (0.13 TU; 30% of test time in clean water) but less preference (44% of time in clean water) for 8% effluent (0.15TU). Possible effects of salinity, pH and effluent colour on the avoidance response is in progress.

Olfactory detection of pulpmill effluent by salmonids appears quite sensitive. Coho gave a moderate olfactory bulbar response to 1% effluent (.02 toxic units) with maximum response in the 5-20% range. The threshold response appears to be in the 0.1-1% range.

Field studies of chum salmon avoidance were carried out during July and August, 1975, using the facilities of the L. PACIFICA while moored near the Port Alice pulp mill. Fish were tested for preference of Pacific Environment Institute water carried aboard *vs.* surface water from Neroutsos Inlet. The apparent absence of effluent contamination in the local waters (Secchi disc 9.5 - 10.5 m at the test water location) during the pulp mill strike probably accounted for failure of the fish to show an avoidance response.

Preliminary work on the behaviour of fresh and saltwater coho fingerlings during exposure to toxic and sublethal concentrations of Rexol 25JM1, a pitch dispersant, was carried out. The toxic threshold for this

material appeared to be about 5 ppm, was extremely sharp (within several tenths of a ppm) and it was apparently more toxic to saltwater-acclimated fish. The action of Rexol is to first produce a protracted state of inactivity, equilibrium loss, and feeble swimming behaviour before physiological death occurs. During this period, the fish are probably ecologically dead, hence LC50 determinations have little meaning in relation to fish survival for substances of this kind. In one test, assisted by a video tape recording system operating for 5-minute intervals every three hours, freshwater coho were exposed to 5 ppm Rexol for 14 days. Loss of response to shadows and movement over the test tank accompanied by thigmotaxis occurred within 2-5 days exposure. By eight days, the fish were lying on the bottom of the tank showing only occasional opercular beats, but would attempt to swim when touched. During this phase, fish responded to mechanical vibrations of the tank wall. On the 17th day, recovery was started in water without Rexol. After about 18 hours, equilibrium had been recovered and the fish again showed thigmotaxis. Within three days, normal alertness to shadows and movement returned. After six days recovery, the feeding response was normal. On the basis of three "physiological" deaths during the test, time to 50% mortality was estimated to be >1000 hrs, "ecological" death was estimated to be 64 hrs.

Work on organization of a session on "Environmental Physiology of Aqueous Gases" during 1974 culminated in May 1975, with the Electrochemical Society Conference in Toronto. The session attracted only a small audience of physical scientists attending the conference sessions but the after-session discussion of the group was most enthusiastic.

3. University Student Research

(a) Graduate Students

G. M. Kruzynski
(Ph.D. Program)

In collaboration with Dr. D. Randall, Department of Zoology, University of British Columbia, Mr. Kruzynski is pursuing his graduate research under direction of Dr. Davis at PEI. The program deals with osmoregulatory capability of migrating salmonids exposed to isolated kraft pulp mill waste components. This work is believed important due to the siting of a number of pulp mills in areas close to estuaries where migrating salmon undergo salinity acclimation. Potentially, a toxic stress, coupled with salinity stress and need for osmo-adaptation, could prove to be particularly critical to migrating salmonids.

Results indicate that dehydroabietic acid (DHAA) is more toxic to underyearling sockeye salmon (*Oncorhynchus nerka*) in fresh water than in sea water. In contrast, the unsaponifiable neutrals extracted from kraft mill waste appear more toxic in sea water than in fresh water. Acute exposure to DHAA in fresh water results in bloating and general weight gain attributable to increased muscle water content. Preliminary results indicated that after 21 hours exposure to 1 mg/l DHAA in fresh water, sockeye plasma osmolarity, chloride and sodium were depressed while plasma potassium, calcium and magnesium were elevated. These findings support the hypothesis that kraft mill waste components interfere with osmotic balance in salmonids.

(b) Undergraduate Projects

R. Zuk
G. Iwama
(B.Sc. Programs)

Two studies carried out by UBC undergraduates for senior course requirements were supervised by Dr. Greer. In one study by R. Zuk, attempts were made to condition fish to the presence of low concentrations of effluent using electric shock as the conditioning stimulus. An experiment of this type is useful in determining the concentration of KME required before higher level neural processing of the olfactory response by the fish takes place. The results of the study were inconclusive, owing largely to the severe constraints on time available to the student. In the second study, G. Iwama measured several hematological parameters of freshwater coho exposed to 0.75 ppm dehydroabietic acid under flow-through conditions and three levels of swimming exercise. Lowered total white cell counts and increased blood clotting times were found, with the higher level of exercise (*ca.* 2 body lengths/sec swimming speed) seemingly ameliorating the DHAA effect. Mr. Iwama is presently enrolled as an M.Sc. student and will undertake studies at PEI on the effect of KME exposure on disease induction in coho (expected date of completion - Spring, 1977).

B. ECOLOGY

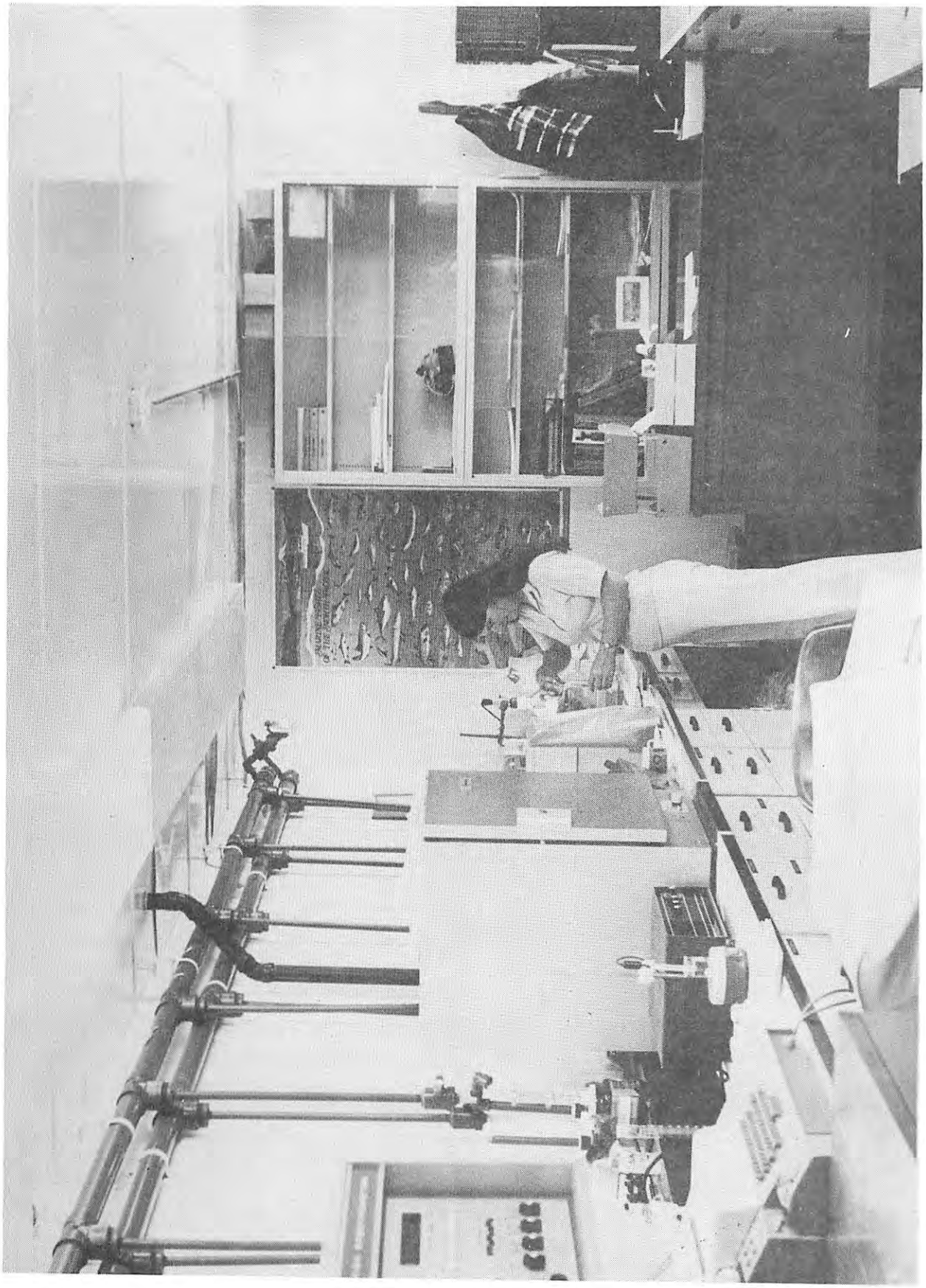
Phytoplankton studies were continued in freshwater and marine environments both in the laboratory and in the field. With the transfer to PEI of Dr. N.J. Antia from the Vancouver Laboratory of the Fisheries and Marine Service, studies of effects of certain natural and artificial factors on axenic cultures of phytoplankters were able to supplement ongoing work on the effects of environmental changes on phytoplankton production in marine situations. Benthic ecology studies concentrated on estuarine environments, particularly in the Squamish and Fraser River estuaries.

1. Phytoplankton and Benthic Algae Ecology

(a) Physiological Studies on the Ecology of Marine Phytoplankton

N. J. Antia

Physiological studies were made with axenic cultures of marine microalgae to examine the effects of certain natural, as well as man-made, environmental stresses on their viability and growth. A large proportion of species showed remarkable capacity for surviving several months of total darkness and this capacity showed temperature effects traceable to the ecological origins of these species. Exposure of the phytoplankters to borate concentrations of 5-100 ppm B in continuous light showed that: (i) 10 ppm B was completely innocuous; (ii) 50 ppm B caused partial inhibition of growth which was generally overcome after adaptation; and (iii) 100 ppm B was totaly inhibitory to growth of about 35-40% of the species tested, but was tolerated by the remaining species often after gradual adaptation.



Plankton ecology laboratory with a technician preparing samples for analysis

(b) Marine Studies

J.G. Stockner
D.D. Cliff
A. Costella

The phytoplankton program was expanded in 1975 to include 12 stations in the Strait of Georgia and 5 in Burrard Inlet. Visits to 10 stations in Howe Sound were reduced to allow time to collate and analyze data gathered from April 1972 - January 1975.

(i) Howe Sound:

Production in Howe Sound at stations affected by Squamish River turbidity is generally light limited, while at stations removed from any direct influence of the Squamish River, phytoplankton production is nitrate limited. The most productive regions of the Sound were those furthest removed from river influence, where production ranged from 500-1500 mgC $m^{-2}day^{-1}$ during the growing season. Those stations affected by river turbidity and/or stain from pulp mill effluent exhibited production ranging from 100-500 mg m^{-2} day^{-1}.

(ii) Strait of Georgia:

Preliminary analyses showed much higher production in the Strait of Georgia than in Howe Sound, notably in regions removed from Fraser River turbidity. Plume values ranged from lows of 250 mgC m^{-2} day^{-1} off the Fraser to 4500 mgC m^{-2} day^{-1} off Sangster Island.

(iii) Burrard Inlet:

Productivity in Burrard Inlet was greater than average from Howe Sound, but was less than at most stations in the Strait of Georgia. The most productive region was off Port Moody where production averaged 1200 mgC m^{-2} day^{-1}. Production decreased at each of three stations in a seaward direction, with the least production seen in outer Burrard Inlet off PEI, averaging 600 mgCm^{-2} day^{-1} .

(iv) Pulpmill Effluent and Primary Production

Data were gathered in 1975 from special incubation experiments in a stain gradient off both Woodfibre and Port Mellon. A significant linear relationship between production and light extinction coefficients, verified the importance of light affecting primary production adjacent to pulp mills.

Axenic pure culture studies with *Skeletonema costatum*, *Dunaliella tertiolecta*, and *Amphidinium carteri* have demonstrated some toxicity at high concentrations (30-40% KME in sea water), but basically a surprising ability to adapt to concentrations higher than those normally encountered *in situ*, given sufficient time, i.e. 20-30 days. Evidence from both field and laboratory studies in 1975 indicated that light attenuation by KME is a far more serious problem than toxicity.

(v) Squamish River Estuary (W.Martin Pomeroy - Ph.D. thesis work):

Production studies of both macro and micro attached algae have continued in 1975 with emphasis on the energetic relationship between algae and the

dominant invertebrate (amphipods), and rates of import-export of algae from caged areas. Heaviest utilization of algae occurs in February and March, coincident with peak production by both algae and amphipods. Highest export occurs in the November-December-January period.

(c) Freshwater Studies

One primary study in Carnation Creek, on Vancouver Island, and an ongoing monitor program in Babine Lake comprised the freshwater effort of the plankton ecology group.

(i) Carnation Creek:

Studies were continued in 1975 to assess levels of autotrophic production in Carnation Creek and its estuary, and in Ritherdon Creek, on an adjacent clear-cut logged watershed. A number of parameters were assessed for their effect on production. Light is low under the forest canopy, but removal of canopy does not result in significant increases in production (production in Ritherdon Creek was as low as in Carnation Creek). An experimental trough was installed to test for nutrient limitation, and results showed an immediate doubling of production when nutrient levels were increased to twice background. On the basis of these experiments, nutrients, not light, are considered the limiting factor to trophic production. Of the two important nutrients, phosphorus was considered in shortest supply.

Average standing stock levels of chlorophyll *a* in Carnation Creek and Ritherdon Creeks in 1974-75 were among the lowest ever recorded in the literature. Rates of organic accumulation (net production) were similarly low and point to an ultra-oligotrophic nutrient-limited, rain-forest ecosystem.

(ii) Babine Lake:

As part of an ongoing OECD-based lake monitor program, production, chlorophyll *a*, light and temperature studies were carried out in May-June, 1975, on Babine Lake. Results showed no significant increases in productivity above 1973 levels, and copper concentrations in water at two locations adjacent to tailings dumps from a copper mine, appeared low enough so as not to inhibit phytoplankton growth at that time.

2. Benthic Ecology

C.D. Levings
N.G. McDaniel

(a) Squamish River Estuary - Howe Sound

(i) On-going Benthic Ecology Research

Observations on the long-term impact of the dyke construction and river diversion (1972) continued at the Squamish estuary. An extensive survey of 115 benthic stations was completed to document community changes in the central sector of the delta. Visual observations on the low spring tides showed that relatively stenohaline forms such as *Nereis* sp.and *Bankia setacea* had moved into deeper sections of the central basin, providing further evidence for the increased marine character of this sector. Sampling for amphipod (*Anisogammarus confervicolus*) biomass and population structure was resumed at

the central sector, with emphasis on differences between the sedge rhizome habitat and shallow tidal pools on the marsh proper. Salinity, temperature, and dissolved oxygen data gathered over the past two years were compiled and prepared for publication as a data report.

Sampling at times of low river runoff showed that the salt wedge can penetrate 2 km upriver. On one occasion "high" salinity water ($25^0/_{00}$) flowed via culverts from the river channel to the central basin, where because of elevation differences, the salt wedge is not normally present. These observations suggest that the culverts, installed in 1972 at considerable expense, may not be achieving their apparent goal of providing fresh water for the central basin.

Although some new species have colonized the habitats behind the river dyke, the species composition of the amphipods remains unchanged. In particular, *Gammarus setosus*, a slightly more stenohaline amphipod than *A. confervicolus*, has not moved into the central basin from habitats on the Mamquam delta (1 km distant). Basket traps containing rockweed (*Fucus* sp.) were tested as quantitative sampling devices for estuarine amphipods. The distribution and abundance of amphipods in baskets were similar to patterns observed by more laborious techniques such as quadrat sampling. The baskets might also be useful for "mass capture" of amphipods, as huge numbers (up to 10,000) of animals were recorded in 10-day sets. A note was prepared on the technique.

As a contribution to energy flow studies at the delta, the net primary production of sedge (*Carex lyngbyei*) was estimated at 1300 g dry wt m^{-2}season $^{-1}$ (1974 data). Percent increase in biomass day^{-1} reached a maximum of 11% in April and May. Aerial photography was used to document colonization of sedge affected by silt spillage due to hydraulic dredging (1972). Plants in small tidal creeks, where silt was relatively thin, had recovered but in other sectors biota had not been able to penetrate the sediment (8 to 10 cm thick). Observations on sedge were prepared for publication.

(ii) Graduate Student Research

Progress was made on several thesis projects being conducted under the auspices of the benthic ecology program in Howe Sound and at Squamish. A Ph.D. thesis on the energetics and population ecology of barnacles (*Balanus glandula*) continued by R.S.S. Wu. Barnacles were successfully grown in a variety of statistical distributions on plexiglass plates at the PEI wharf. Barnacles transplanted to near the Port Mellon pulp mill survived for four months but all died after start-up of the mill following a prolonged shut-down. Barnacles transplanted to the central sector of the Squamish estuary suffered high mortality during the summer runoff period, but the mortality rate decreased in autumn. Growth rate at the estuary was much slower than at control populations at PEI.

Studies for an M.Sc. thesis on the feeding ecology of juvenile salmonids at the Squamish estuary were initiated by D. Levy. Test fishing for abundance and stomach samples (gill nets, beach seines; monthly sampling) has shown that a wide variety of fishes utilize the central sector of the estuary (juvenile chinook, chum, cutthroat, dolly varden, shiner seaperch, cottids). Subsequent work will focus on feeding ecology of juvenile chinook

salmon on amphipods, mysids and isopods under a variety of turbidity levels.

An M.Sc. thesis project on the ecology of the deep sublittoral benthos of Howe Sound was also initiated by H.G.Christie. This project focuses on differences in community structure in relation to oceanographic features (especially low oxygen) on either side of the Anvil Island sill. Results to date show that south of the sill (Strait of Georgia), biomass and species diversity are higher than at similar depths within the Sound.

Analyses of quadrat samples from disrupted and intact beaches on Howe Sound (mini deltas) were completed. Results are being blended with photographic evidence in a report which is near completion.

(b) Fraser River Estuary

(i) Benthic Studies Related to the Vancouver International Airport Expansion

Results of ecological studies at the Fraser River estuary were reported in two technical reports and a conference publication. Data resulting from surveys carried out as part of the environmental assessment program, related to expansion of Vancouver International Airport, showed that benthic biomass was clearly zoned. The highest biomass values (average 35 g wet wt m^{-2}) were recorded in finer sediments adjacent to emergent vegetation. Similar or higher biomass values were recorded in eel grass (*Zostera marina*) beds in the low intertidal zone on southern Roberts Bank. Salinity data from the surface of sediments (at low tide) showed how jetties and causeways deflect fresh water from the river, influencing patterns of distribution of biota.

(ii) Effects of Iona Island Sewage Treatment Plant Effluent

Sewage discharged over Sturgeon Bank has a considerable ecological impact on benthos and has led to a degraded zone adjacent to the outfall. Mudflat communities in the upper intertidal zone were less affected by the sewage compared to sand-flat assemblages. On transects through the degraded zone, species diversity in mud habitats paralleled patterns for biomass and number of individuals. In sandy areas, a pattern noted in many other studies was observed. Species diversity decreased as a peak in biomass and number of individuals was reached at a certain distance from the affected area. Further analyses of the data are underway using canonical analysis and clustering techniques.

Utilizing the sparse data at hand from the entire estuary, a biomass pyramid in energy units (Kcal m^{-2}) was constructed for primary producers, primary consumers, and secondary consumers on the mudflat ecosystem. The pyramid was similar to those reported for detritus-based systems, emphasizing the role of emergent vegetation and heterotrophic production in energy flow patterns. The disruptive effects of industrial activity on energy flow patterns could be examined. Further biological information, especially productivity in relation to sediment type, needs to be obtained before realistic models can be built for predictive purposes.

Benthic ecology laboratory with examination of benthic samples in progress

(iii) Recolonization by benthos following hydraulic ditching

On Roberts Bank, a study was initiated to document the speed and pattern of re-establishment of benthic communities subsequent to disruption by hydraulic ditching. The ditching is to provide burial for B.C. Hydro power lines leading to Vancouver Island. Communities at the study area are dominated by amphipods (*Corophium insidiosum*), sabellid polychaetes (*Manayunkia aestuarina*), and a tanaid (*Tanais* sp.). Differences in species composition and biomass between the crests and troughs of sediment "waves" (amplitude 10 to 20 cm) were noted. These differences may feature in the recolonization pattern depending on configuration of the ditch after burial of the cable. The project will also provide data on "normal" seasonal fluctuations in estuarine benthic communities, information which is not yet available for B.C. waters. Samples for benthic biomass, species composition, chlorophyll, grain size, temperature, and salinity are being frequently obtained (2 week intervals) at a control and experimental station. Technical assistance is being provided by a contract biologist and the project is partially funded by B.C. Hydro and Power Authority, Environmental Resources Department.

(c) Other Projects

(i) Benthic Studies in B.C. Estuaries

A manuscript report was published presenting information on sampling sites for intertidal biota at a number of estuaries on the B.C. coast. These estuaries have been examined as "control" locations for work on the disrupted estuary at Squamish. Macrobenthos and sediments were sampled at the Cowichan River estuary as part of a general biological survey organized by Fisheries Operations and Pacific Biological Station (PBS). Amphipod basket traps were also tested in the work.

(ii) Recolonization of Mine Tailings

While at the Bamfield Marine Station, Dr. Levings completed a reconnaissance survey of an abandoned mine tailings disposal area at Toquart Bay, Barkley Sound; results were reported later in a manuscript report. The soft-shell clam (*Mya arenaria*) was the only macrobenthic organism that had colonized the tailings. A variety of infaunal organisms were observed in the magnetite sand which had spilled from the loading facilities.

(iii) Long-term Effects of Wood Waste

Further biological samples of sediments containing wood debris were obtained at an abandoned pulp mill (Swanson Bay) and at Ocean Falls. The Swanson Bay samples showed organisms living among undecayed wood at least 30 years old. Fibre loss at the Ocean Falls groundwood mill is one-third the level previous to 1973, but there has been no noticeable improvement in bottom oxygen levels or condition of the sediment.

C. POLLUTANT CHEMISTRY

In the POLLUTANT CHEMISTRY section, work continued on both organic and inorganic environmental contaminants. The organic chemists pursued problems related to effluent disposal from the pulp and paper industry as they affect fisheries in both toxicity and flesh tainting. Inorganic chemists concentrated on problems associated with metals from mine tailings and on the uptake of copper by salmonids. The chemists worked closely with biologists and ecologists at the Pacific Environment Institute as well as with groups in other establishments, e.g. the International Pacific Salmon Fisheries Commission laboratory at Cultus Lake and the CEPEX (Controlled Ecosystem Pollution Experiment) project in Saanich Inlet.

1. Organic Chemistry

I.H. Rogers
H.W. Mahood

(a) Foam on Biobasins at Pulp Mill

This project was concluded during 1975 with presentation of a joint paper by Dr. J.A. Servizi at the 1975 Environment Improvement Conference of the CPPA at the Hotel Vancouver, October 15, 1975. The paper was also submitted to the Journal of the Fisheries Research Board for publication.

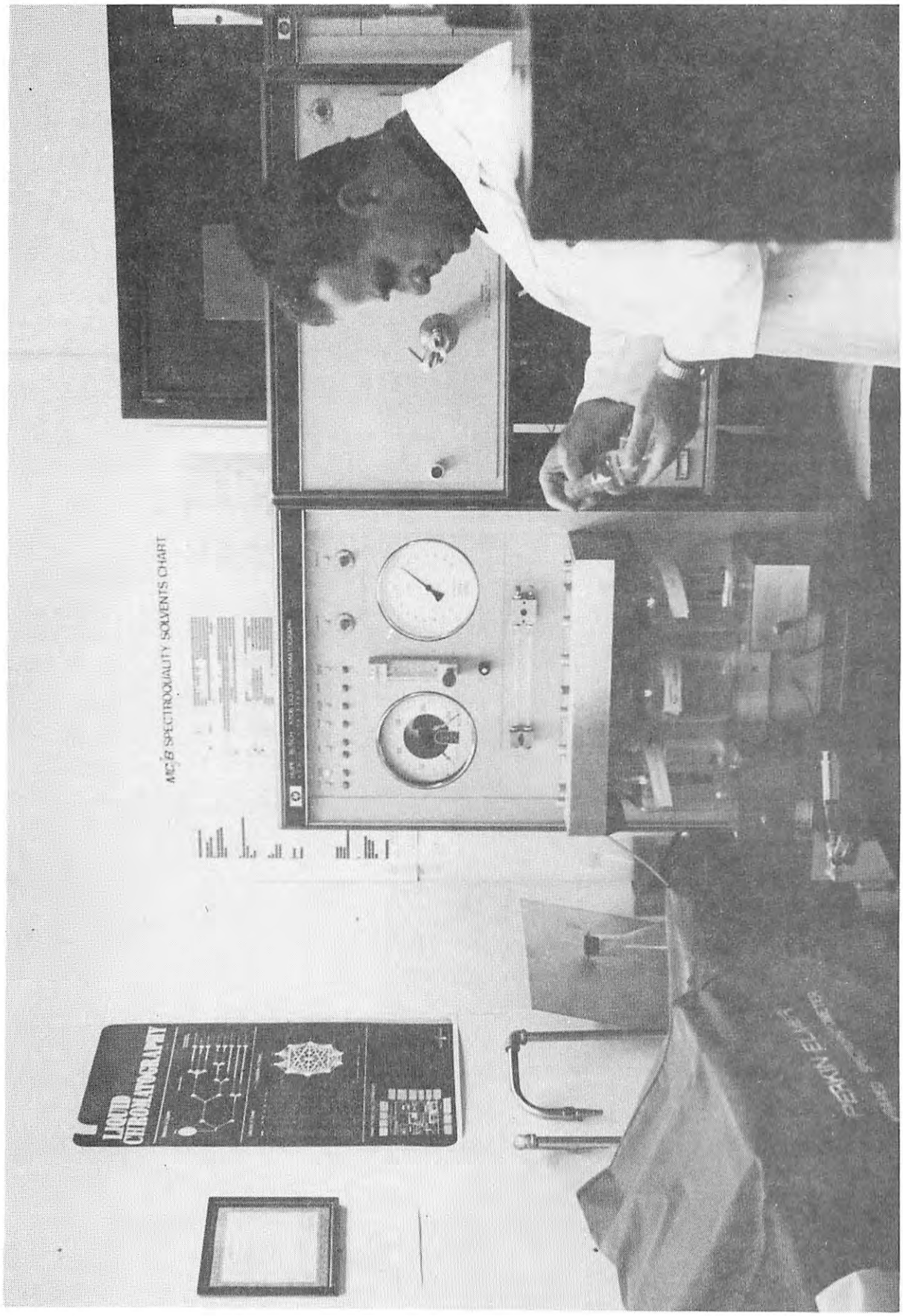
Foam collected at both pulp mill lagoons was highly toxic to juvenile sockeye salmon. Chemical fractionation of one foam revealed a large amount of toxic resin acids and neutral diterpenes. In the other foam, toxicity was related to a pitch dispersant and unidentified substances. The NMR (nuclear magnetic resonance) spectra of a foam extract *versus* a mill addition used for pitch control are shown in Figure 1. Neither foam was readily detoxified by biological treatment in the laboratory.

(b) Fish Tainting Studies

Fraser River eulachons were intercepted and exposed in the laboratory to three concentrations of biologically treated whole mill effluent from the kraft pulp mill at Kitimat. After 24-hour exposure, the animals were sacrificed and their flesh was sampled by a taste panel. Fish exposed to 80% and 8% concentrations of effluent were rated low in both flavour and odour, whereas fish exposed to 0.8% effluent were indistinguishable from the controls. Head space analyses of fish samples heated in sealed containers have been conducted by gas chromatography with a flame photometric detector. Volatile sulphur compounds were detected in the flesh of the exposed fish at levels increasing with degree of exposure. More work is required for identification of these compounds and to search for other less-volatile organosulphur compounds.

(c) Organochlorine Compounds in Bleach Plant Effluent

Much effort has been spent in attempts to synthesize the four possible isomers of trichloroguaiacol. To date, only one of these compounds has been prepared. 4,5,6 trichloroguaiacol has an LC50 value of 1.1 mg/l to juvenile sockeye salmon and was found at levels up to 0.63 mg/l in samples of caustic extraction effluent from a coastal mill. Tetrachloroguaiacol



The organic chemistry analytical instrument room

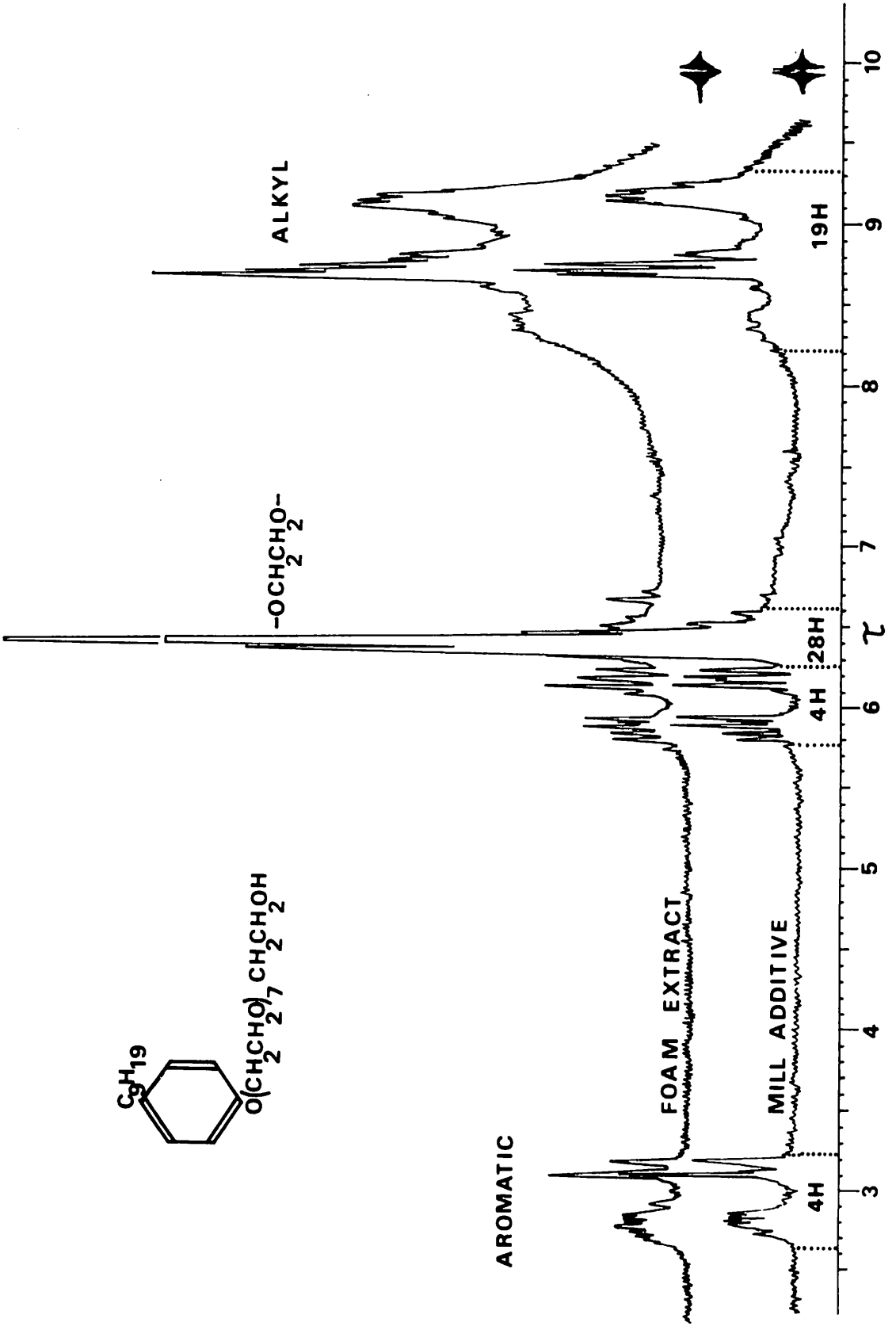


Figure 1. NMR spectra of the neutral fraction from foam B and a nonionic pitch dispersant (mill additive).

was also synthesized and found to have an LC50 value of 0.44 mg/l to juvenile sockeye. This compound was detected at concentrations up to 0.14 mg/l in the mill samples already mentioned. Both compounds were detected in a fish-toxic sample of whole mill effluent after biological treatment in a 5-day aerated stabilization basin. Over 100 compounds were detected in this sample, many of them chlorinated. This gives rise to concern as to how effectively such compounds are removed in conventional secondary treatment systems.

2. Inorganic Chemistry

J.A.J. Thompson
D.W. Paton

(a) Mine Tailing Studies

In 1975, a strong emphasis was placed on field programs. From data obtained in 1974, as part of our mine waste study, it was determined that considerably more and varied samples would have to be collected. To this end, a total of four cruises were made to three mine sites: Rupert Inlet, Howe Sound and Texada Island. Extensive samples of sediment and water were obtained for analysis for copper, zinc and iron content.

Of particular interest were data obtained for sediment interstitial waters from Rupert and Holberg Inlets, Quatsino Sound and Howe Sound, which indicated no discernible increase of copper in samples from submerged mine tailings when compared with those from natural sediments. The data for the pore waters also indicated that dissolved copper concentrations in samples from Howe Sound can be up to 7 times as high as those of samples from the Quatsino Sound area. This is probably a reflection of differing geochemistries in the two study areas.

Recently further core samples were obtained from 24 stations in Howe Sound. It is anticipated that data obtained from analysis of core sections and pore waters will provide further information on the nature of copper distribution in this important water body.

Samples of sediment and water from the Strait of Georgia near Texada Island were collected for survey purposes.

(b) Copper Uptake Experiments in CEPEX

This section was very fortunate this year to have the opportunity to participate in the CEPEX program. Two experiments were conducted using the full-sized bags, 30 m deep by 10 m in diameter with a volume of 2000 m.tons. Both were designed to study the uptake of copper by the chum salmon *Oncorhynchus keta*. The first experiment was curtailed because of failures in the flotation collars of all but one of the bags. Only samples of fish exposed to a copper concentration of 2.5 µg/l were obtained. There were no controls except for those taken before dosing commenced.

The second experiment was conducted with three test bags having newly constructed flotation collars. One bag was used for a 2.5 µg/l test exposure while the other two were controls. Samples were collected by personnel of this group, weighed and dissected as soon as possible after

collection. The gills, muscle and viscera of 15 fish from each of 4 sampling dates were later analysed for copper by flameless atomic absorption spectrophotometry. There are, as yet, insufficient data to indicate whether the fish had increased copper concentrations above the controls.

(c) Professional Development

Both Dr. Thompson and Mr. Paton had the opportunity to attend professional development courses in 1975. Both attended a one-day workshop on the applications of thin-layer isoelectric focusing techniques in biochemistry. This was intended as an aid to future research with the protein, metallothionein. Mr. Paton also attended a two-day course on atomic absorption techniques sponsored by the Perkin-Elmer Corporation.

D. OCEANOGRAPHY AND MARINE POLLUTION

Studies continued in this section utilizing largely available oceanographic data obtained in past surveys. Oceanographic support in field work was provided to other investigations at the Institute. Some laboratory experimental work was conducted on diffusion of oxygen into seawater systems of different vertical characteristics.

1. Fisheries Oceanography

A.J. Dodimead
H.G. Christie

(a) Subarctic Pacific

Studies were continued in collaboration with U.S. and Japanese scientists on the oceanography of the Subarctic Pacific Region, as a national commitment to the International North Pacific Fisheries Commission (INPFC). A second joint report, entitled "Oceanography of the Subarctic Pacific Region, 1960-71" was completed and submitted to each of the national sections for their review and approval. The report is now in the hands of the INPFC Secretariat for publication as an INPFC bulletin.

A report, "Canadian Oceanographic Research in the Subarctic Pacific Region", was prepared for the 22nd Annual Meeting of INPFC. Information on sea-surface and subsurface (100 - 125 m depth) temperature conditions at Ocean Station P, and sea-surface temperature conditions along Line P for 1972 and 1973 were presented. Sea-surface temperatures at Ocean Station P were slightly higher in 1973 during January - April than in 1972. However, by the end of May, conditions had reversed, and for the remainder of the year, sea-surface temperatures were 1 - 2 C^0 higher in 1972 than in 1973 (Fig. 2).

In the subsurface waters (100-125 m), generally opposite conditions to those in the surface waters prevailed. Temperatures were about 0.5 - 1.5 C^0 greater in 1972 during January - February than in 1973. During March - April similar conditions prevailed, but for the remainder of the year, subsurface temperatures were higher in 1973 than in 1972, particularly from mid-August to December, when temperature differences ranged from 1.0 - 1.5 C^0 (Fig.2). The relatively large temperature differences, as noted in January - February and in August - December, were a result of the presence of two distinctly

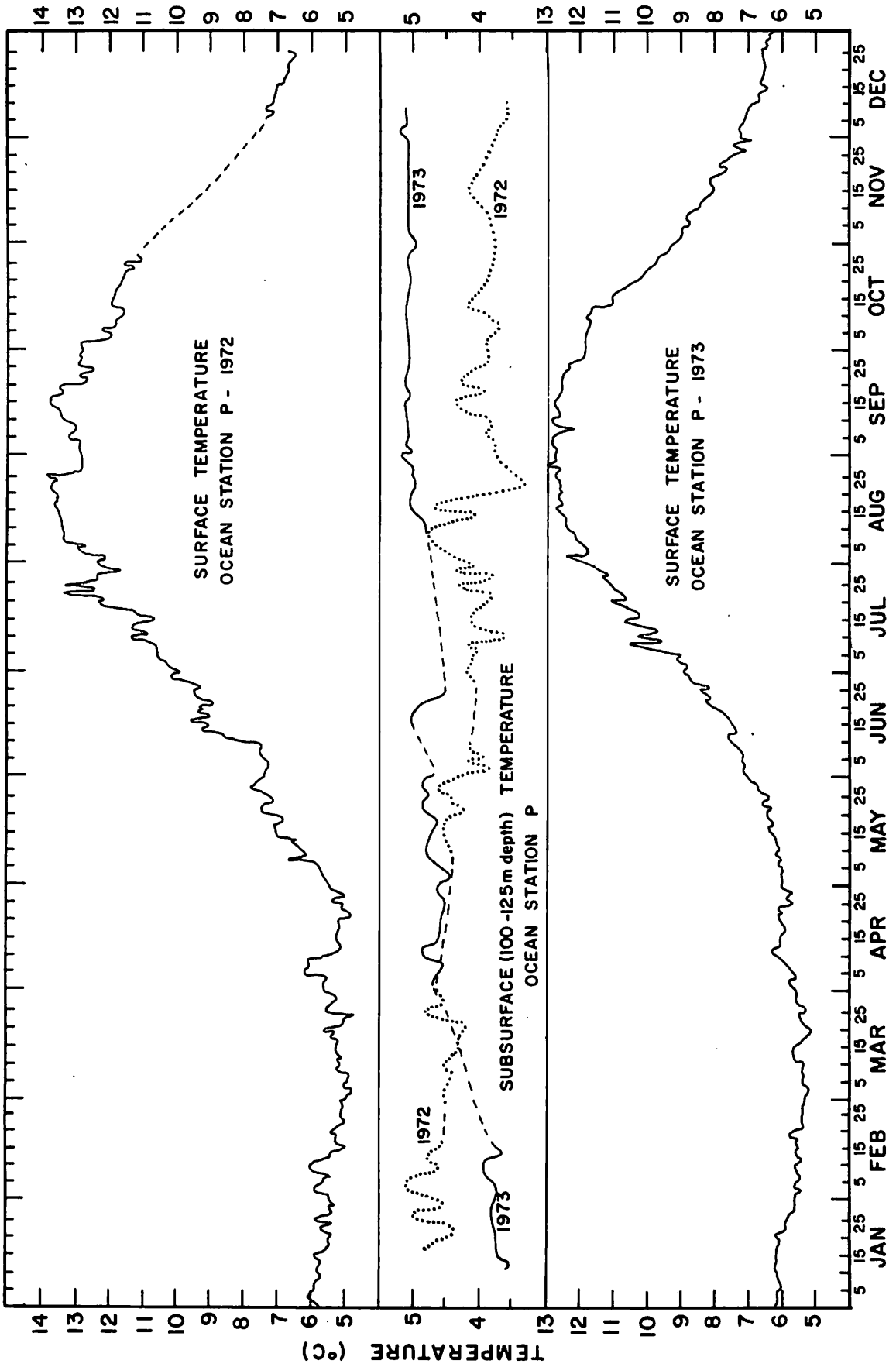


Figure 2. Surface and subsurface temperatures (°C) at Ocean Station P, 1972-1973.

different temperature structures at Ocean Station P. During the periods when subsurface temperatures were relatively low (3.5 - 4.0^{0}C) a marked temperature-minimum stratum between 100 - 125 m depth was present (Fig. 3). However, during January - February 1972 and August - December 1973, the temperature-minimum stratum was essentially non-existent, and within the upper part of the halocline (at approximately 125 m depth), the temperature structure was nearly isothermal, with temperatures slightly greater than 5^{0}C(Fig.4).

Along Line P, similar heating and cooling trends occurred as at Ocean Station P, and from May - December surface temperatures were about 1 C^0 higher in 1972 than in 1973.

(b) Queen Charlotte Sound, Hecate Strait and Dixon Entrance

A review of available oceanographic data and research results for Queen Charlotte Sound, Hecate Strait and Dixon Entrance has been initiated. Further analyses of data in Queen Charlotte Sound and Hecate Strait is underway to provide additional information on the oceanography of these two areas. Such information is timely because of the current research on the fisheries in these areas, and also the concern of the effects of industrial pollutants, particularly hydrocarbons, on the coastal waters and living resources.

2. Marine Pollution

M. Waldichuk

No field surveys were conducted during 1975. Past oceanographic reports and data were utilized in describing the characteristics of a number of estuaries in the series of reports being prepared for the Estuary Working Group of the DOE Regional Board Pacific Region. Oceanographic sections were written for the reports on the Fraser, Squamish, Skeena, Cowichan and Chemainus River estuaries.

Laboratory experiments were conducted on the rate of diffusion of dissolved oxygen into "still" sea water with a stable (positive) vertical temperature gradient. With homogeneous salinity distribution in the test container, the diffusion of atmospheric oxygen into the sea water, stripped of most of its dissolved oxygen content, was comparatively rapid (about 96 hours to reach near saturation). Judging from tracer tests with rhodamine B dye solution, this was apparently a result of convective movements set up by lateral temperature gradients in the test container.

When a stratified system was established in the test container, by covering the O_2-stripped sea water with a layer of fresh water, the oxygenation of the sea water was markedly retarded. In runs of one-week duration, oxygenation of the sea water was not perceptible until the stratification broke down when the fresh water mixed into the sea water after about 4 days.

Results of these experiments demonstrate in part the reason why atmospheric oxygenation of deep water in quiescent, salinity-stratified systems in nature does not occur rapidly. This has certain implications in coastal water disposal and marine pollution.

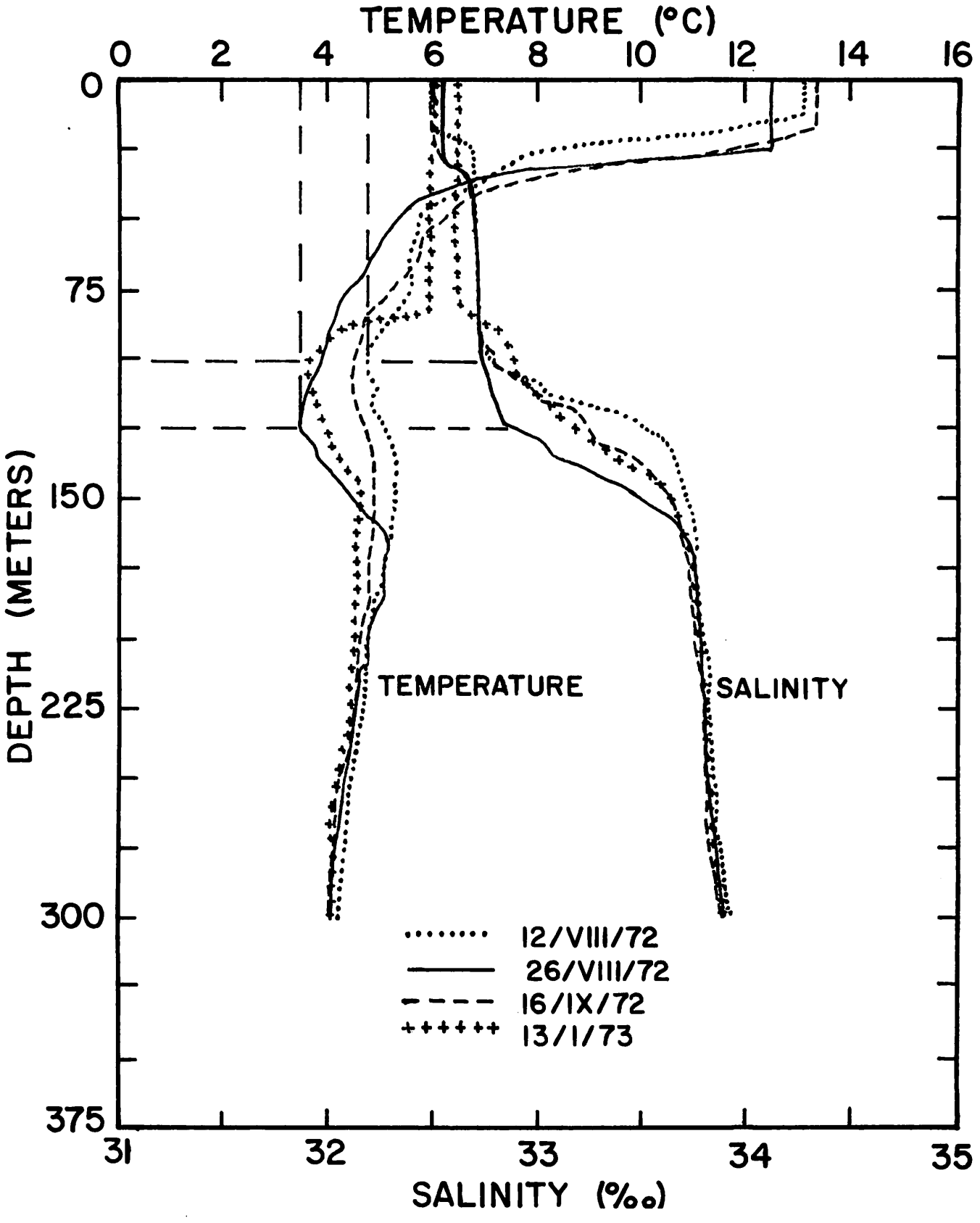


Figure 3. Temperature and salinity structures at Ocean Station P, August - September, 1972 and January, 1973.

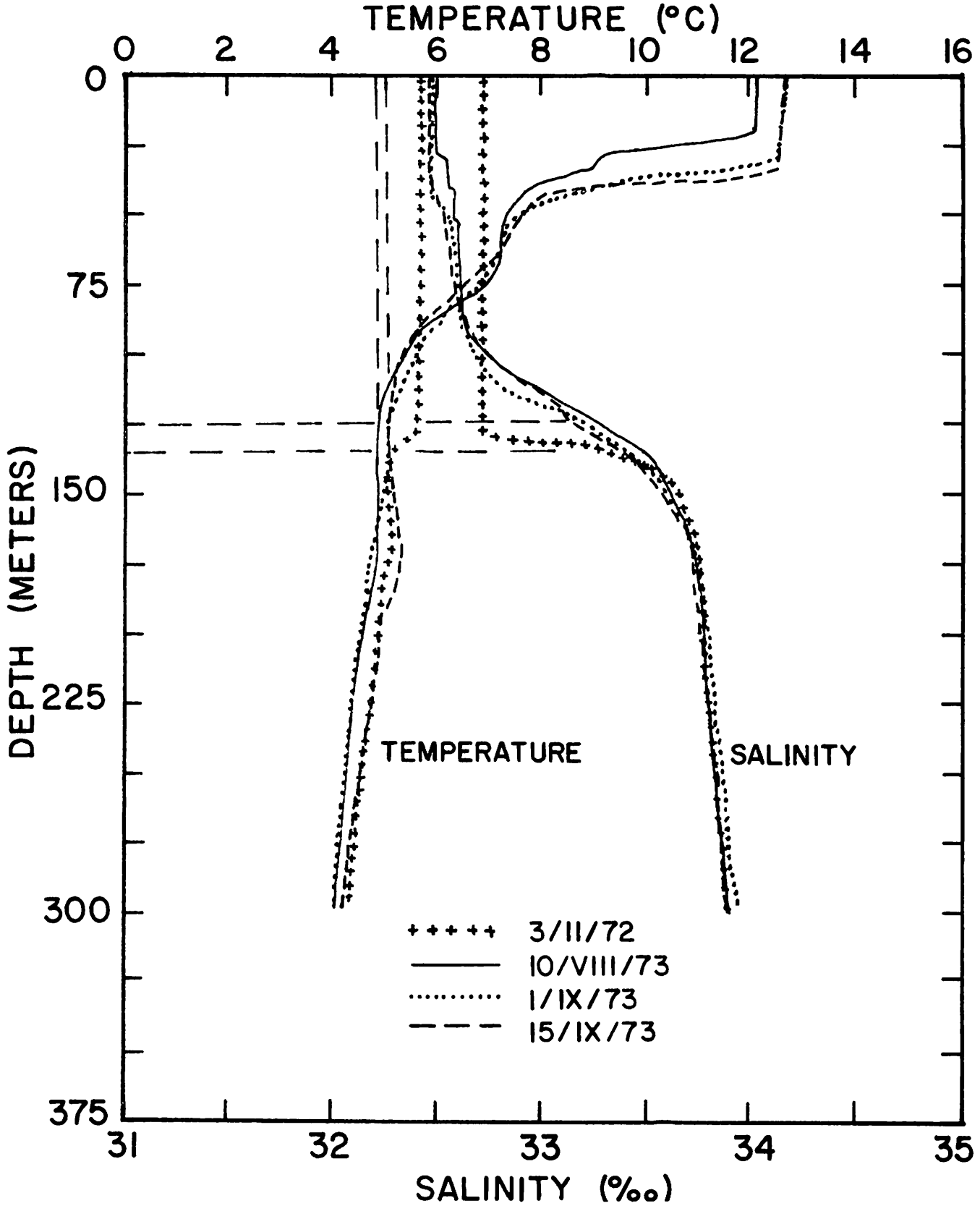


Figure 4. Temperature and salinity structures at Ocean Station P, February, 1972 and August - September, 1973.