INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT — 1979

INSTITUTE OF OCEAN SCIENCES
Sidney, B.C.

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March, 1980

CONTENTS

DIRECTOR-GENERAL'S OFFICE

C.R. MANN

T. Van Dusen - Secretary

*A.B. Cornford - Head, Program Analysis and Liaison

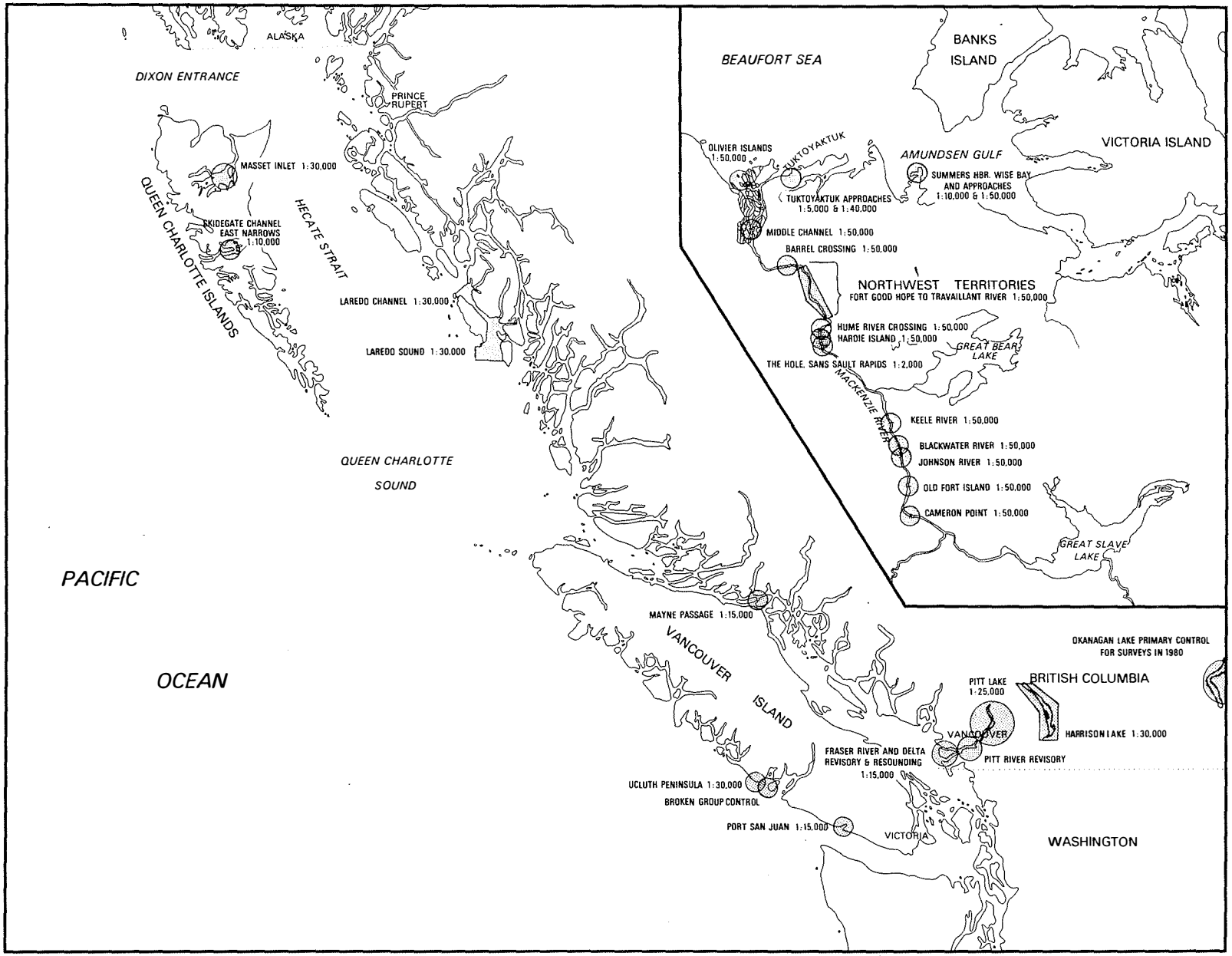
1979 is the second year that members of the Institute of Ocean Sciences have occupied the new building at Patricia Bay. It has been a year during which the various groups have developed a spirit of togetherness in their diverse endeavours, as distinct from their rather isolated existence before they were housed in the same building. The Institute was formally opened by the Governor General, His Excellency the Right Honourable R. E. Schreyer on February 28, 1979. A picture of Mr. Schreyer with Dr. R. W. Stewart on his left forms our title page.

Several changes in our senior staff have taken place. Dr. Stewart left on executive exchange with the Province of British Columbia in mid-year. He was replaced by Dr. C. R. Mann who transferred from our sister institute, the Bedford Institute of Oceanography on the east coast. Dr. P. W. Nasmyth, the Regional Oceanographer, retired in June, and Mr. R. W. Sandilands was appointed Regional Field Superintendent in the Hydrographic Division.

As usual fiscal restraints are still with us; we lost one half of our capital budget for this year, but the difficulties imposed upon us have been offset by the enthusiasm of our staff in developing the hydrographic and oceanographic programs. There is a great deal of work that needs to be done off our west coast and in the western Arctic. It will all get done, eventually, but only at the pace we can set with our present resources. I doubt it will be fast enough to meet the burgeoning commercial developments.

Two developments that augur well for the future are the signing of an agreement between the Federal Government and the Provincial Government of British Columbia for the lease of land opposite the Institute to develop a Marine Technology Centre devoted to the development of marine industry, and the move by OAS at the national level to research and produce papers on marine transportation in the Arctic, ocean climate, and on other subjects of national interest. The inauguration of the Centre follows many years of assistance in the development of Marine Industry by IOS through contracts, and the DSS unsolicited proposal route in support of the government's Make-or-Buy policy. If it develops as it should, the Centre will greatly strengthen the marine sciences on the west coast. Perhaps with the presentation of well-thought out papers on marine science we can obtain the resources we need to meet the growing demand for marine research.

*Acting Regional Oceanographer - July-December 1979



Pacific Region 1979 Hydrographic survey program

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

S. B. McKenzie - Secretary

The year's activities were predicated, to a large extent, by the governmental climate of fiscal restraint. The reduction in the available operational and capital resources combined with reduced purchasing power of the dollar resulted in an inevitable restriction of field activities. This was particularly noticeable in the Arctic, where the high cost of operations and logistic support precluded the mounting of a major field program. Nonetheless, significant work was accomplished in various areas of the region.

The high priority assigned to the completion of surveys in the Beaufort Sea has been reflected in several ways. Studies have been contracted to examine methods for detection of many pingo-like shoals in the area. Short and long term planning for future major survey programs in cooperation with the oil industry have been undertaken. Internal and external negotiations for logistic support for Arctic programs is continuing.

Miscellaneous programs for various agencies involved considerable time and effort. The Canadian Coast Guard Vessel Traffic Management Radar Monitoring System was calibrated. Displays and tours were designed for the Canadian Power Squadrons. Specific surveys were undertaken at the behest of the Pacific Pilotage Authority, Canadian Coast Guard, and the British Columbia tourist industry. A map and brochure showing the federal fishing and recreational harbours was produced for the small Craft Harbours Branch. Positioning equipment and personnel were provided for the DEMR gravity and magnetic survey of Hecate Strait.

A major internal program involved the Tidal and Current Survey section which devoted considerable time, personnel and resources to the Coastal Ocean Dynamics Experiment, in close cooperation with the Offshore Oceanography section. A high level of support was provided to all elements of the Institute by Computing Services and Engineering Services.

Personnel changes saw the retirement of Ralph Wills after 25 years of service and the appointment of R. W. Sandilands to replace Mr. Wills as Regional Field Superintendent. W. J. Rapatz was confirmed in the position of Regional Tidal Superintendent and K. R. Holman was appointed Production Chief in the Chart Production and Distribution Section.

FIELD HYDROGRAPHY SECTION

Regional Field Superintendent - R. Wills*
- R.W. Sandilands***

F.A. Coldham
J.V. Crowley
K.L. Czotter
G.H. Eaton
B.M. Lusk
R.I.D. May
P.R. Milner
A.R. Mortimer
A.D. O'Connor
R.D. Popejoy
M.L. Preece
A.R. Raymond
G.E. Richardson
E.D. Sargent
R.U. Schoenrank
C.R. Tamasia
W.P. Van Duin
J.A. Vosburgh
M.M. Ward
D.J. Wood
M.V. Woods

Head, Sailing Directions — R.W. Sandilands until 12 November
Acting Head, Sailing Directions — A. Smith from 13 November
L.M. Wakefield

Head, Hydrographic Development — J.B. Larkin
A.J. D'Aoust
**R.I.D. May
**P.R. Milner

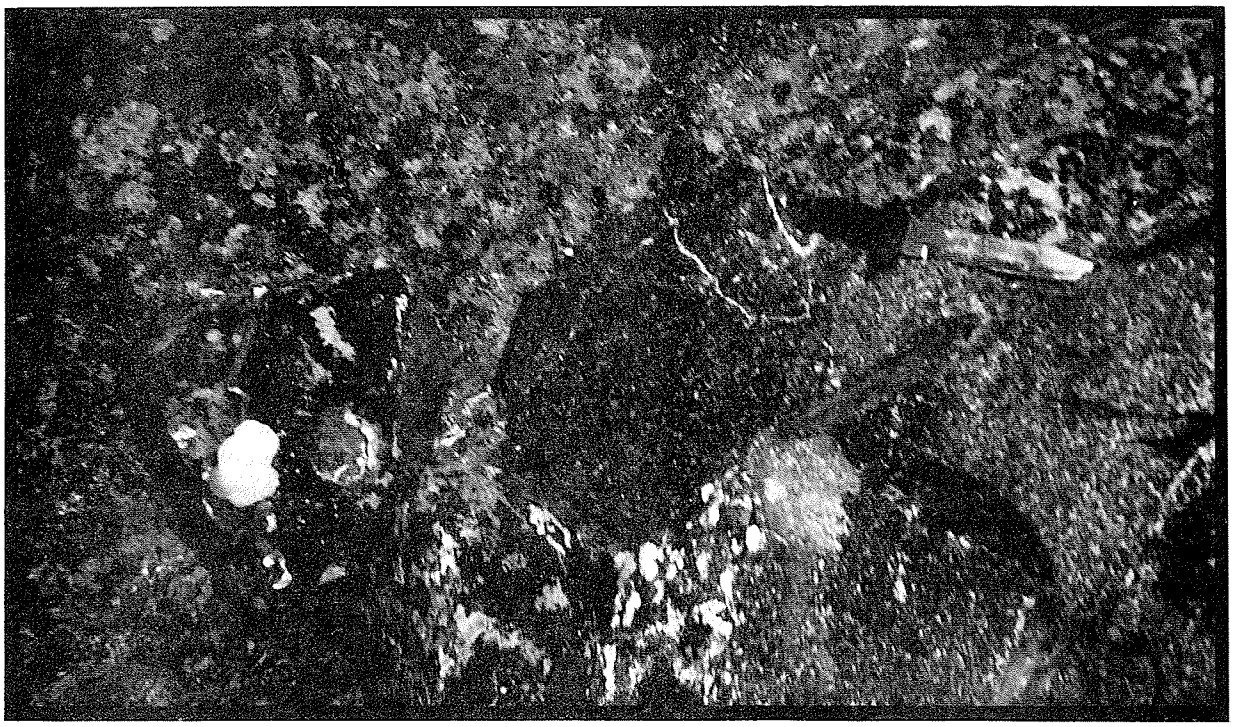
*Left during 1979
**Rotational Staff in Hydrographic Development
***Promoted

The main hydrographic work on the B.C. coast in 1979 was carried out by a large party with Mr. Lusk in charge. Operations commenced in April with surveys of Harrison Lake and River which are previously unsurveyed highly used recreational areas. The main lake was completed by the end of May and work on the river was suspended on 8 June to allow the party time to transfer to CSS *Parizeau* for the major coastal survey of the season, a resurvey of Laredo Sound and Channel.

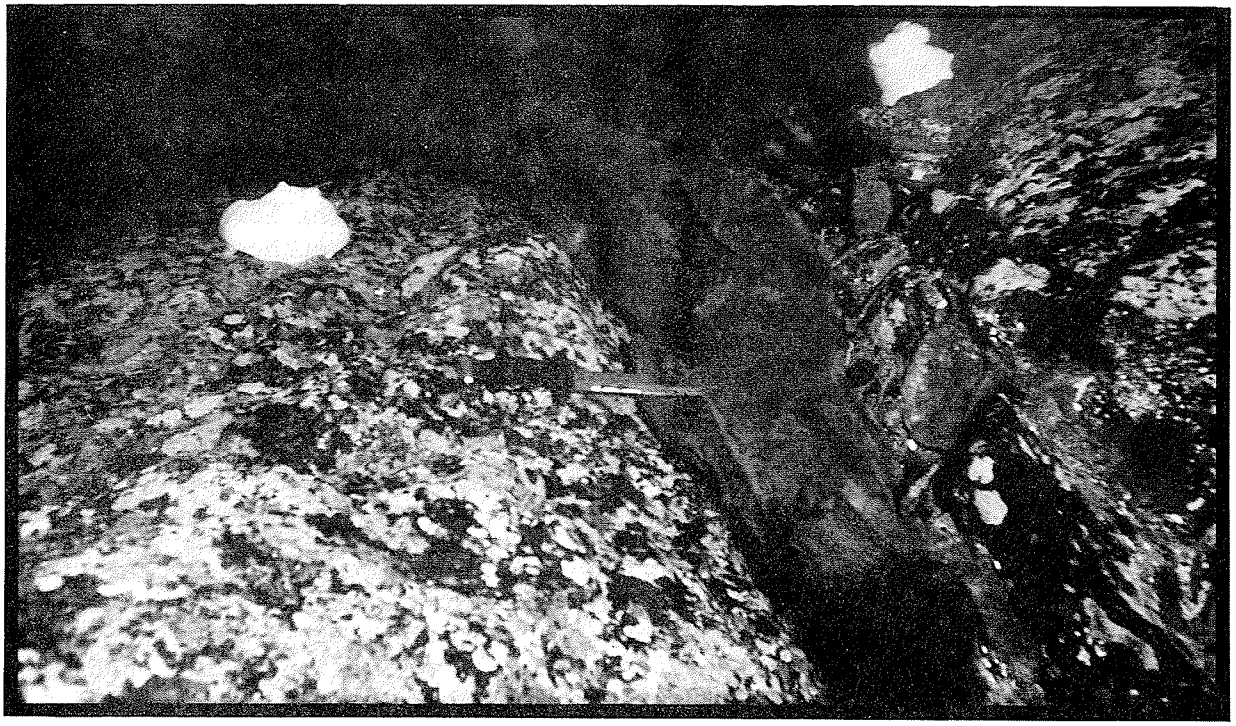
On 14 June *Parizeau* sailed for survey. Participating in this survey for experience were Mr. Sander, an instructor in surveying at Camosun College, Victoria and Mr. Idigo, a surveying student from Nigeria. The area was complex and over four hundred shoals were examined, several of these being known shoals which were, on examination, found to have less water over them than charted. Notice to Shipping and to Mariners action was taken. The survey was completed on 23 August.

The rationale for these surveys was the provision of modern charting for the deep-draught ore carriers en route to Kitimat. One of these carriers hit an obstruction in Laredo Sound in the vicinity of Wilson Rock in early November. A small party, including divers, under the charge of Mr. Lusk and accompanied by a Department of Transport Investigating Officer embarked on

CSS *Vector* and returned to the area. After positioning themselves over a reported shoal in the vicinity of the position claimed by the pilot the divers went down and found portions of the ship's bottom and other evidence to confirm that the ship had indeed struck a reported shoal.



Broken pieces of rock in the vicinity of the grounding



The diver's knife is pointing to a large piece of metal off the ship's hull

The survey of Harrison River was recommenced on 4 September and was completed by 13 September. A subparty then travelled to the Okanagan Lake to carry out some preliminary work for the 1980 field season. This party completed operations at the end of September.

The second B.C. coastal survey party was conducted on CSS *Richardson*, with Mr. Vosburgh in charge. They commenced the season with a resurvey of Mayne Passage between east and west Thurlow Islands. Next they surveyed Port San Juan, previously surveyed in 1932, and this was followed by completion of work started in 1978 on the outer coast of the Ucluth Peninsula. While in this area some preliminary survey control was established in the Broken Group in Barkley Sound. In July the party moved to the Queen Charlotte Islands where Skidegate Narrows and its ranges were surveyed. The remainder of the season was spent in Masset Inlet where a resurvey was completed before the party returned to Sidney on 23 September.

A shore party under Mr. Richardson divided its activities between the B.C. Coast and the Western Arctic. It started the season with a resurvey of selected sections of the Fraser River delta. These were areas previously sounded in 1974 and the object of the work was to duplicate those surveys and thus provide sedimentologists of the Geological Survey of Canada with an on-going record of changes in the delta. A survey of Pitt Lake was completed in May and June and in July the party went north for two months. On its return south in September the Fraser River delta survey was completed and revisory work done in the Fraser River, Pitt River and Lake and in Vancouver Harbour.

The projected cruise of *Pandora II* to the Western Arctic was cancelled for reasons of financial restraint and so surveys in that area were minimal this year. With support from the Canadian Coast Guard and Canmar, the shore party was able to complete surveys of Wise Bay and Summers Bay together with their approaches. A detailed survey of the approach channel to Tuktoyaktuk was also completed.

The M/V *Radium Express*, on charter from Northern Transportation Company Ltd. (NTCL), continued the Mackenzie River survey with Mr. Crowley as Hydrographer-in-Charge. The program concentrated on the lower portion of the river below Fort Good Hope although several short stretches upstream from there were sounded. The most recent buoy and range positions were fixed for the total length of the Mackenzie River. Since 1972, hydrographic surveys of the Mackenzie system have been conducted annually using the NTCL charter vessel *Radium Express* but, in view of current restraints and CHS national priorities, the project has been terminated.

Surveillance of the artificial islands in the Beaufort Sea was continued with a set of photographs being taken in August.

The Navigation Group headed by Mr. Mortimer undertook several projects during the year. One of the major ones included an investigation of low frequency navigation systems coverage in the Western Arctic and the implementation of the BIONAV integrated satellite navigation system onboard CSS *Parizeau*. The new Loran C transmitter at Port Hardy was positioned and support was given for projects carried out by other disciplines at the Institute and the Pacific Geoscience Centre (PGC).

In November, a small hydrographic field party provided assistance to the Ministry of Transport in calibrating the Mount Newton radar monitor which is an integral part of the Vessel Traffic Management system, Vancouver Traffic Control Centre.

Eleven staff from hydrography attended the International Hydrographic Technical Conference held in Ottawa in May and two of these, Mr. Bolton, Chairman and Mr. Sandilands, Publications, were active on the organizing committee for this, the first such technical conference.

The Region hosted the field training portion of the Hydrography I course and provided HQ staff with additional training support.

Sailing Directions

The Sailing Directions Section revises and maintains two volumes of Sailing Directions and two volumes of Small Craft Guides. New editions of these volumes are published on a two year cyclical basis.

The fourth edition of B.C. Small Craft Guide, Volume I, Vancouver Island, Port Alberni to Campbell River including the Gulf Islands, was published in May. This publication continues to be very popular with the recreational sailor with sales of over twelve hundred in the first eleven months of the year.

The eleventh edition of B.C. Sailing Directions (South Portion), Volume I was received from the printer in December.

Sailing Directions for Kootenay Lake and River, Chart 3050, a strip chart in book format which includes Directions, were amended to include new information gathered during a field revisory survey. These Directions were passed to the Chart Compilation Section for chart production action.

New editions of B.C. Sailing Directions (North Portion), Volume II and B.C. Small Craft Guide, Volume II, Boundary Bay to Cortes Island, are under preparation for publication in the 1980/81 fiscal year.

The section participated in a revisory survey contract during the year and the only field work carried out involved helicopter flights to obtain new photography for Small Craft Guide, Volume I.

Hydrographic Development

Mr. D'Aoust has been seconded to Canada Centre for Remote Sensing, in Ottawa, to work full time on the Aerial Hydrography Project. The contract with P.A. Lapp, Ltd. is proceeding on schedule, with a flight test being conducted during the summer in the Thousand Islands area of the St. Lawrence River. Mr. D'Aoust is the scientific authority for the contract, and is also involved with improvements to the track recovery system using previous data obtained by flying over an accurate test range in Arizona. Results of

test flights conducted to date are promising, and indicate the possibility of Arctic production flights in 1981.

Hydrographers R. May and P. Milner joined the group for their rotational assignment.

It was intended to carry out field trials of NAVBOX units but due to manufacturing delays the units were not available, and trials have been postponed until next year.

Mr. Milner familiarized himself with the Kongsberg flatbed plotter, and assisted field parties in preparation of field sheet base plots and survey lattices.

Mr. Milner also made a field trip to the Western Arctic with A.R. Mortimer conducting Loran C monitor tests, and later assisted with the data reduction.

CHART PRODUCTION AND DISTRIBUTION SECTION

W.S. Crowther - Regional Chart Superintendent

R. Bell - Supervisor New Chart Production
P. Browning - Navigational Aids
G. Chan
D. Dobson - Nautical Information
E. Earl
M. Farmer
D. Fisher - Supervisor Chart Sales
J. Gould
D. Harrison - Supervisor Chart Correction
M. Hohl
K. Holman - Production Chief
**S. Huggett
K. Josephson
*B. Kenny
R. Korhonen
D. Kynoch
A. Lyon
*M. Mikkelsen
**P. Morton
**G. Neilson
**R. Parker
M. Patton
A. Philp
L. Pickell
R. Pierce
A. Ross - Quality Control
N. Said
**J. St. Gelais
R. Taylor
L. Thompson - Quality Control
B. Watt
G. Whincup

* Joined during 1979
** Left during 1979

Chart Production

The main effort of the Chart Production Section in 1979 was chart maintenance. New Chart production was impeded by the resignation of three cartographers and the transfer of one other to the Atlantic Region. One cartographer attended the Cartography I course at Headquarters.

Despite setbacks because of limited resources, accomplishments in chart production must be considered successful. One specific highlight in New Charts was the commencement of production for 3311, a Small-craft strip chart of the Sunshine Coast.

The relocation of Chart Distribution and Chart Correction activities away from Chart Production, and the subsequent relocation of the Technical Records Unit adjacent to the production units has helped to make regular activities more efficient.

A new Ozalid machine was purchased and installed in the Photo-Mechanical Unit. The relocation of the venting system contributed to a more efficient and reliable reproduction capability. A small contact frame was received and is being installed, permitting the simultaneous processing (contacting) of very small and very large copy at any given time without interference.

There were a number of non-charting activities undertaken during 1979. The largest undertaking in this area was the Small-craft Harbour map for Small Craft Harbours Branch which includes a comprehensive facilities listing. About 450 other miscellaneous projects were undertaken for all units of the Institute. They ranged from half-hour photographic jobs to forty-hour drafting projects.

The number of requests for information and copies of survey documents from the private sector continues to grow. An average of eight telephone queries are handled daily by our Nautical Information Officer.

The rotation of senior cartographers into the Quality Control Unit continued through most of 1979 whereby working level cartographers spent two-month periods on assignment. This has given participants an opportunity to demonstrate their ability and management an opportunity to assess their capabilities.

Chart Production hosted a number of tours for individuals and groups directly associated with chart-making. The largest of these groups consisted of 125 members of the Victoria Canadian Power Squadron. A second Canadian Power Squadron (CPS) tour for the Brentwood Squadron turned out about 50 members. Also, a total of three displays were prepared including the CPS Display which will be made available on loan to CPS Squadrons across Canada.

As usual, distribution of charts reached its peak in mid-summer. Delays due to volume in mid-summer were as high as ten days but complaints regarding delays were at a minimum. Chart Distribution embarked on an advertising program which began with the circulation of two Newsletters to all Chart Dealers in the Region. Efforts are being made to maintain closer contact with Dealers, thereby improving the service to chart users.

In Automated Cartography the following graphics are now being generated on the Univac 1106 computer and drawn on the Kongsberg flatbed plotter:

1. fully graduated borders, international style;
2. small-craft borders;
3. hyperbolic navigational lattices, including Loran-C;
4. wind velocity charts;
5. grids.

Cartographers in Chart Production are now being trained in the use of these programs and are using them in the production of charts. Cartographers are also using a GOMADS program to produce borders for compartment charts and for charts with insets. The MOSAIC program is now operational but has not yet been used in production. This program generates source file data at varying scales and produces projections to a common file.

Chart Production and Distribution personnel including summer students photographed on one of several terraces at the Institute of Ocean Sciences. June 1979.

The digitizing program was received from Ottawa and was modified to handle the Talos digitizing table and to run under the RSX11M operating system. Also, the Talos system had the following modifications:

1. the interface was modified to give the system the same functional capabilities as the Gradicon table;

2. a beeper/talk box was designed and built by Institute Electronics;

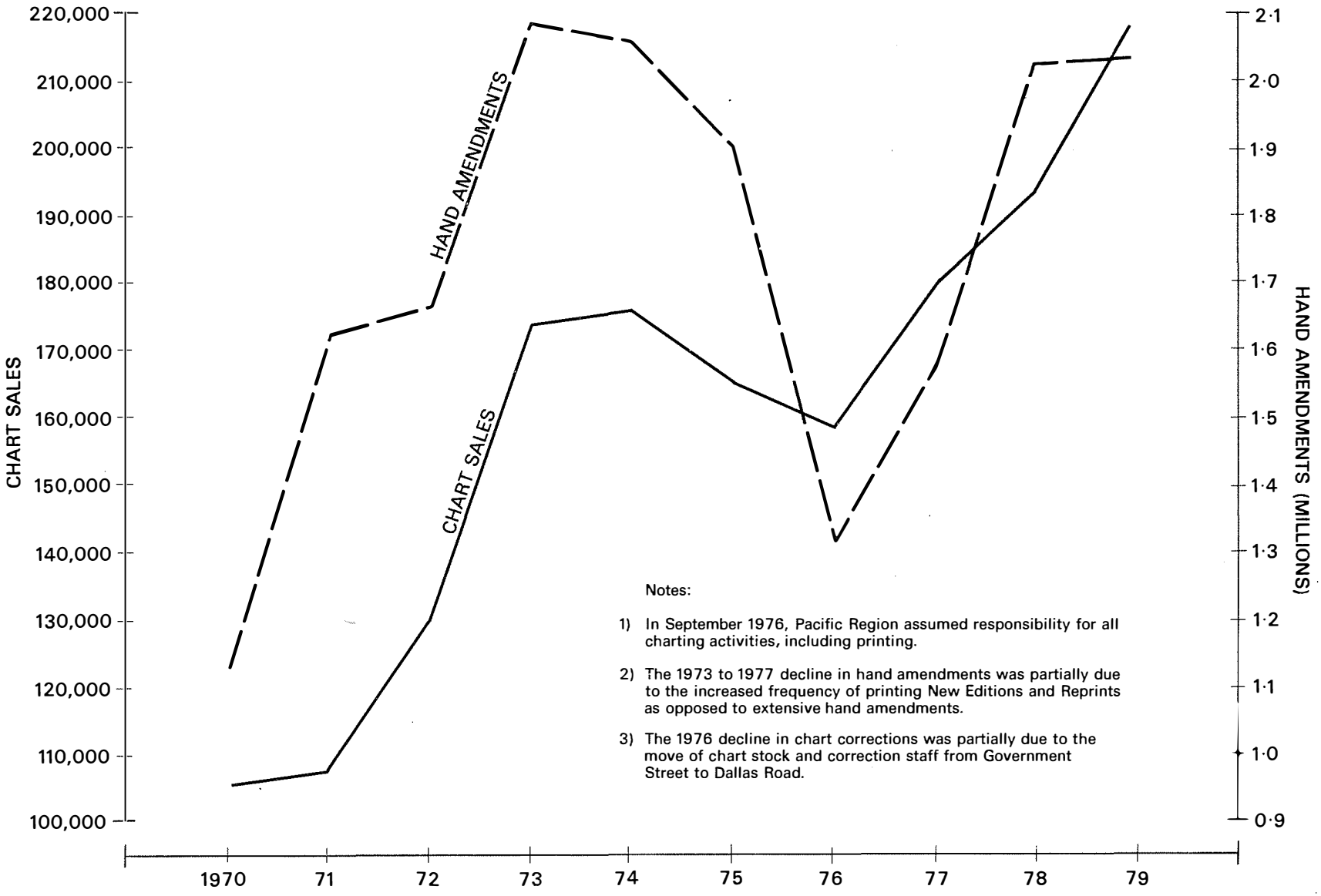
3. a scribing cursor was designed and built by contract.

The digitizing table had unacceptably large errors and was sent back to the factory for repairs.

Production & Distribution Statistics 1979

New charts published	6
New editions published	61
Preprints published	16
Overprinting of existing chart stocks	1
Notices to Mariners	107
Notices to Shipping processed	13
Chart patches printed	6
Number of charts corrected	197,500
Chart corrections (hand amendments)	2,158,317
Total charts distributed	224,110
Total publications distributed	74,073
Dealerships inspected	36
New dealerships established	20
New Small-craft dealers	15
Dealerships withdrawn	5
MAREPS processed	306

Pacific Region: Chart Sales & Hand Amendments



Notes:

1) In September 1976, Pacific Region assumed responsibility for all charting activities, including printing.

2) The 1973 to 1977 decline in hand amendments was partially due to the increased frequency of printing New Editions and Reprints as opposed to extensive hand amendments.

3) The 1976 decline in chart corrections was partially due to the move of chart stock and correction staff from Government Street to Dallas Road.

TIDAL AND CURRENT SURVEY SECTION

W.J. Rapatz - Regional Tidal Superintendent

A.B. Ages - i/c Hydraulic Research
R.E. Brown
W.R. Crawford - i/c Tidal Research
A.N. Douglas (Computing Services)
G. Ellison
W.J. Harris
F.V. Hermiston
W.S. Huggett - i/c Current Surveys
*K.S. Lee (Computing Services)
A.C. Ma
A.J. Smedley
F.E. Stephenson - i/c Tidal Survey
M.J. Woodward
A.L. Woollard (Computing Services)

*Joined during 1979

1979 was an extremely busy year for this section. In January W.S. Huggett and W.R. Crawford were assigned to be part of the FGGE project on the equator, and both men spent six weeks aboard CSS *Parizeau* obtaining current and current shear measurements across the equatorial undercurrent to define its limits. Six transects of the equator were made between 2°N and 2°S. A free-fall microstructure instrument was also deployed 45 times to measure microstructure shears and temperature gradients.

In May, Current Surveys combined with Offshore Oceanography in a study of the waters on and adjacent to the continental shelf on the west coast of Vancouver Island, part of the Coastal Ocean Dynamics Experiment (CODE). Thirty-five current meters were deployed along two lines running out from Estevan Point and Brooks Peninsula. All moorings were successfully retrieved and re-deployed in September, and work is underway on the analysis of the first set of data. Instruments will remain in place until September 1980.

Field work for the survey of the Gulf Island passes and Quatsino Narrows was completed, all tide gauges were recovered, and analysis of the data is underway, which will give better current predictions for inclusion in the Tide Tables.

Hydraulic Research continued its measurements of salinity and currents in the Fraser River in order to determine the behaviour of the salt wedge and to support a study of the migration pattern of salmon, requested by Department of Public Works for its Fraser River Shipping Improvement project.

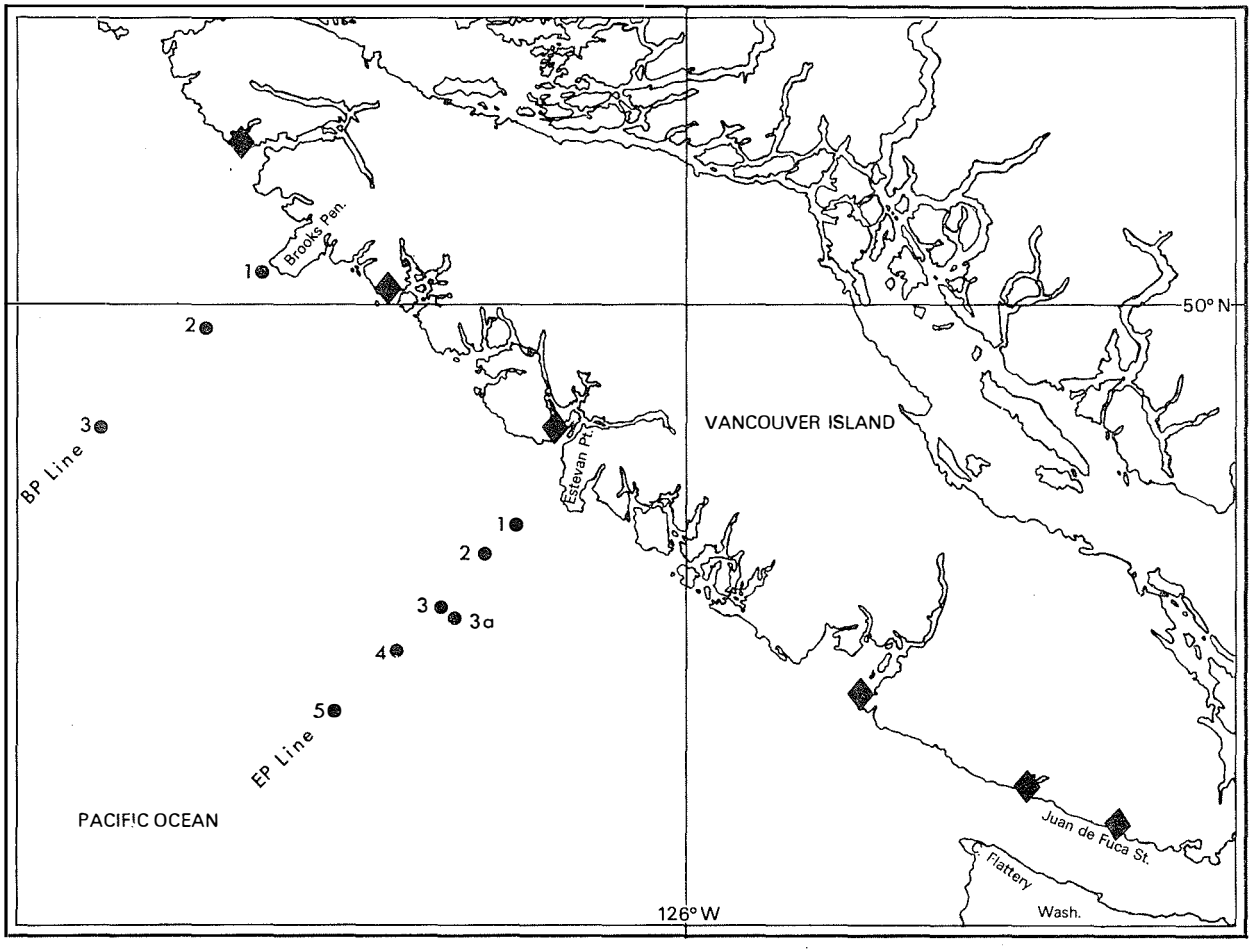
Production runs of the existing mathematical model of the Fraser River were made at the request of various government and private agencies.

A field program of current, salinity and temperature measurements was carried out in the mouth of the Skeena River. Oil spill simulation models were developed to provide information for various oil port enquiries. Surface drift measurements were carried out in the western part of Juan de Fuca Strait, in cooperation with the Pacific Marine Environmental Laboratory

in Seattle. These measurements were made to test and improve a model predicting the course of potential oil spills in that area.

Tidal Survey carried out two surveys in the Arctic. One, in conjunction with the tidal group in Atlantic Region, where the records are being analysed, was the installation of three tide gauges in Peel and Franklin Straits and Prince Rupert Inlet. These gauges were recovered in June after two months' deployment. In mid-August eight pressure gauges were installed in Coronation Gulf, Queen Maud Gulf, St. Roch Basin and the connecting waterways. Three pressure gauges were deployed as barometers, and all instruments will be recovered next year.

The data from the twenty-three permanent and four temporary tide gauges are processed and analysed on a routine basis, and processing is now much more efficient with the introduction this year of a disc-oriented data processing system. Four TATS (Tidal Acquisition and Telemetry System) units were installed this year at Vancouver, Point Atkinson, Victoria and Bamfield.



COASTAL OCEAN DYNAMICS EXPERIMENT (CODE). ● Current meter mooring positions. ◆ Shore tide guage positions. EP line positions 1, 2, 3a & 5 have offshore tide guages.

Tidal Research completed a study of the combined effects of weather and tides upon sea levels at periods longer than two days at four British Columbia ports, and this will be published as an Institute report in 1980. The study showed large oceanic responses to air pressure and wind changes west of Vancouver Island.

As part of the Coastal Ocean Dynamics Experiment six pressure gauges were deployed in near-shore waters along the west coast of Vancouver Island and four pressure gauges were moored in waters up to 2500 m depth. The study will examine tidal and wind-driven currents and their relation to sea levels along the shore and in deeper waters. The results will improve current predictions for offshore waters and thus aid navigation, fishing and oil spill management.

DIVING UNIT

Regional Diving Officer - F.E. Stephenson

Field Hydrography:	K. Czotter	Tides & Currents:	F. Stephenson
	R. May		M. Woodward
	M. Preece		
	E. Sargent	Coastal Zone:	L. Spearing
	D. Wood		
	J. Vosburgh	Ocean Chemistry:	D. Paton
			F. Whitney
Engineering Services:	J. Galloway		
	B. Hinds	Ship Division:	G. Price

Diving Unit

This is the first year that a summary of the Institute's diving activities has been included in the Annual Report. The diving unit is a very important but nebulous group which at present consists of fourteen qualified divers - ten of whom work in the Hydrographic Division, one in Ship Division, and three in the Oceanographic Divisions. All divers perform other full time functions and their services are utilized by various sections within the Institute on a "fair exchange" basis. The task of trying to achieve this "fair exchange" is handled by the Regional Diving Officer in consultation with the divers' supervisors. The Regional Diving Officer is also responsible for diver health, training and safety, and for the purchase and maintenance of equipment used by the divers. Almost all funding is provided by the Field Hydrography and the Tidal & Current Survey sections.

NUMBER OF DIVES* PERFORMED: 1974-1979

	1979	1978	1977	1976	1975	1974
Ship Division	0	2	4	2	7	9
Field Hydrography (& Engineering Services)	3	15	2	7	2	16
Tidal & Current Survey (& Offshore Oceanography)	81	122	25	11	27	15
Coastal Zone	44	63	16	-	-	-
Ocean Chemistry & Ocean Ecology	4	12	10	-	-	-
Training & Recreation	9	17	10	4	14	17
Miscellaneous	0	1	2	3	9	0
Total	141	232	69	27	59	57

*Definition of "dive" as used in this report:

1. each diver in the water constitutes a dive, i.e. three divers in the water - three dives;

2. if a diver is out of the water more than two hours and then dives again it is a new dive;

3. if a diver dives at several locations then each location counts as a dive (regardless of the surface interval times).

Between 1974 and 1977 the number of dives* performed by the diving unit averaged 46 a year. In 1978 the number of dives increased dramatically to 232 and in 1979 there were 141 dives.

The increased diving activity these past two years was mainly due to the large number of bottom mounted pressure gauges being installed, positioned and serviced using divers. The Tidal & Current Section, Coastal Zone Oceanography and Offshore Oceanography have all benefitted tremendously from these services. Some projects currently underway would not be possible without divers and others, while possible, would yield a lower quality of data.

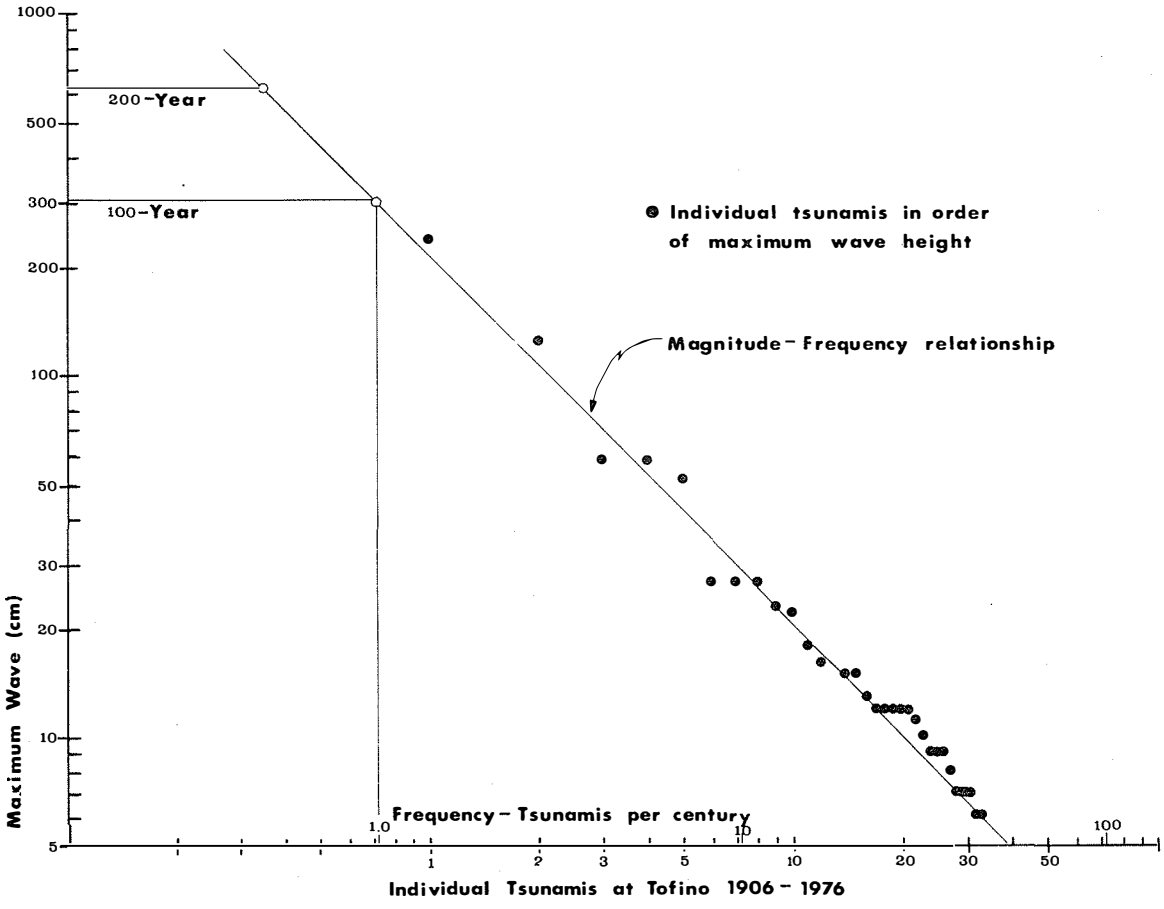
In 1979 divers also conducted important shoal examinations, observed the field tests of new equipment, installed or repaired fluorometer intakes, thermistors, tide staffs and conducted searches for lost equipment.

The diving statistics are heavily biased by the pressure gauge activity, but most dives were to a depth of approximately 15 metres for a duration of 30 minutes or less. Divers spent a total of 55 hours and 17 minutes in the water during 1979. It is anticipated that diving activity will remain fairly constant over the next few years and that the diving unit, as presently structured, will continue to meet the demands of it.

TSUNAMI ADVISER

S.O. Wigen

Investigations have continued to determine the frequency and magnitude of tsunamis to be expected on the Canadian west coast. At Tofino thirty-three had been recorded on tide records in the 71-year period 1906-1976. The largest of these was the Alaskan tsunami of 1964, with a maximum wave height of 240 cm, followed by the 1960 Chilean 126 cm tsunami. Although it is not possible to predict when the 1964 disaster will be equalled or exceeded, a logarithmic plot of the events, as shown on the accompanying diagram, is valuable in estimating the size of a typical once-in-a-century tsunami. Such an estimate is necessary for coastal zone management and for the development of land use policies in areas where tsunamis pose a potential threat.



Efforts to stimulate public awareness of tsunamis have achieved some success. An increasing number of engineering firms are consulting the Institute regarding tsunami hazard during their planning of new industrial and port facilities for low-lying coastal areas.

Resources have been developed at the Institute during 1979 to support tsunami investigation, and a tsunami library of more than 1000 papers has been catalogued and made available for researchers.

Internationally, the Institute took the lead in developing a joint Canada/U.S. report on the use of satellites in the tsunami warning system. The tsunami adviser has participated in tsunami workshops in California and Hawaii, and in tsunami symposia at the Pacific Science Congress, Khabarovsk, USSR and the International Union of Geodesy and Geophysics, Canberra, Australia. Liaison visits have been made to tsunami warning centers at Ewa Beach, Hawaii; Palmer, Alaska; and Tokyo and Osaka, Japan to encourage international co-operation and improved technology for more effective warnings to all Pacific rim countries.

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns
D.B. Smith
S.R. Oraas
J.W. Butcher
A.N. Douglas - Tides & Currents
M.G. Foreman - Numerical Modelling
J.S. Page - Ocean Chemistry
P.J. Richards - Numerical Modelling
A.H. Wharton - FSRG
A.L. Woollard - Tides & Currents
*K. Holtham - Numerical Modelling
*B. Clark
**R.G. Hlady - Management Services
P. Lacroix
*K. Lee - Tides & Currents
*J. Linguanti - Offshore Oceanography

*Joined in 1979
**Left in 1979

Univac 1106 Computer System

The Univac system continued to evolve in 1979 with some hardware changes and software upgrades. A second Fastrand controller was purchased and installed in February; this provides a second access path to the Fastrand drums (used for on-line mass storage). The result has been improved batch through-put and demand response times via reduced I/O contention and consequent access queuing to the drums. To provide the required I/O channel, an on-site 1004 reader/printer was replaced by the former Vancouver remote batch terminal (now operating as a remote 1004, through the communications controller). At the same time, the seldom-used card punch was removed from the system.

In October, a second Uniservo 16 dual density tape drive was installed, replacing one of the older 800-bpi drives. This enables more extensive use of magnetic tapes recorded at 1600-bpi. Also, two more medium-speed (1200 bps) communications ports were added, bringing the total to six at 300, six at 1200, and two at 1800 for asynchronous terminals. The proliferation of computer terminals continued, including an HP 2635A printing terminal with upper and lower-case capability.

A new drum plotter (Houston Instruments DP8S3, with 3 pens) was finally delivered in November. This will replace an old off-line Calcomp 563, and will be driven from the Univac through an on-line controller; software development to support the new plotter has been started.

Software developments included the following:

- The batch scheduling algorithm was revised to give a higher priority and hence a shorter turn-around time for jobs requiring relatively smaller amounts of computer time;
- New versions of ASCII Fortran, COBOL, PL/I, APL, Sort/Merge, Plot queuing, Plot previewing, Tape translation, and the IMSL Mathematical and Statistical library were implemented;
- The LINPACK subroutine library for solving systems of linear algebraic equations was installed;
- An asynchronous communications handler to enable transmission of data from/to foreign devices (such as programmable calculators) was developed;
- The computerized Library Book Catalogue project was resurrected; the database was redesigned, and the data entry program was re-written to be much smaller and faster.

An "Introductory Guide to the Univac 1106 Computer System" was printed in March, and a "Univac 1106 Users' Manual" is now available in machine-printable form. Information relating to recent or upcoming changes to system software, operations policy, or scheduled system down-time was publicized via the "Systems and Operations Notices" series of system news files.

Computing Services staff performed an informal Bench-mark Study in the spring, to determine that the workload statistics ($-value) and rate structure are realistic, when compared to an external service bureau. In the fall, the staff participated in formal bench-mark studies, as part of an evaluation of the Univac 1106, conducted by the Evaluation and Audit Branch of departmental headquarters. A major objective of this study was to determine whether it is cost-effective to continue the operation of the Univac 1106; the final results are expected early in 1980, but preliminary data indicate the system is cost-effective.

Minor adjustments were made in the accounting structure. In August, the overnight rate factor (60%) was extended to cover the entire weekend. In October, a charge was instituted for catalogued mass storage files that are rolled out to tape; this charge is 1/3 of that for on-line files. System utilization levelled off in 1979, as indicated in the following:

Average monthly usage ($)

	1978	1979
OAS users	32,439	31,832
Other users	5,706	9,391
Total	38,145	41,223

Automated Cartography

In 1979 the digitizing system became operational. The digitizing program DIGNTX was received from CHS headquarters in Ottawa. It requires extensive modifications to run under RSX-11M on our PDP-11 minicomputer and to accept our different hardware configuration. A combined beeper and talk box was designed and built by Institute Electronics for connection to the digitizing system. A scribing cursor was designed and built by an outside company. Also, modifications were made to the micro-processor controlled interface for the digitizing table to control the talk box and to give the table the functions required by DIGNTX. The system was used successfully by the Victoria Capital Regional District to digitize property boundaries from a series of map sheets. However, the table was found to have errors which were too large for Chart Production, and was therefore sent back to the factory for repairs.

Cartographers from the Chart Production section have been trained in the operation of the automated cartography equipment and can now produce their own borders and lattices on it. This involves encoding specifications onto punched cards, running them through the Univac 1106, and then making any necessary modifications using GOMADS and other interactive programs on the PDP-11. To assist in the production of compartment charts and borders with insets, a program was written to allow the user to interactively shift and rotate various elements within a graphics file. An additional program was written to assist in the production of wind velocity charts, and these are now being drawn on the Kongsberg photoplotter.

Mini/Micro Computing

Activity in the area of minicomputers and microcomputers in 1979 reflects the trend in computer technology toward distributed intelligence.

The Tides and Currents group moved to a greater use of the multi-user operating system on their Hewlett-Packard 2100 system. Coastal Zone Oceanography acquired a disk drive for their HP2112 system, greatly enhancing the program development capability of that system. The Ocean Mixing Section added a programmer for Programmable Read-Only Memories (PROMS) to their system, which together with an enhanced Cross-Assembler for INTEL 8080/8085 microprograms, provides the Hewlett-Packard users with a very powerful facility for program development for microprocessor-based equipment.

Microcomputing projects this year included enhancements to the SCRIBE high speed data acquisition system and Remote Sensing Section's SPECTRE spectrometer data system as well as the development of the Acoustic Doppler Current Meter (ADCM) jointly by Institute Electronics Engineering Group and Coastal Oceanography Section with Computing Services doing the microprogramming.

ENGINEERING SERVICES

J.V. Watt - Head

Institute Electronics

*** T.A. Curran - Project Engineer	B.A. Johnson
L.W. Dorosh	R. Loschiavo
J.L. Galloway - Project Engineer	R.A. Muse
*** D.G. Gregson	M. Osborne
E.W. Hinds	*M. Stone
C. Hollinger	W.R. Taylor - Head, Technical Support

* Joined in 1979
*** Proceeded on educational leave during 1979

Institute Electronics provides electronics engineering and technical support for survey, research and ship operations in the Pacific Region. The demands made upon the electronics section remained at a high level during 1979 and resulted in the involvement of the staff of engineers and technologists in numerous interesting activities. The capability of the section to undertake engineering projects was significantly reduced this year by the temporary loss of two of the staff who have returned to university to seek advanced degrees.

Electronics Engineering Group

Services to the Institute during the past year involved the usual variety of consultation activities and minor modifications but only a very limited number of major activities. In a departure from the role undertaken in the past, one of the two Project Engineers, Mr. Curran carried his current shear probe beyond the development and test phase into the field to collect data during the 1979 FGGE tropical experiment. In the aftermath of this two month cruise he has spent considerable effort examining the data collected and as of September has undertaken course work at U.B.C. which will lead to a M.Sc. in Oceanography.

A major engineering effort has been applied to the development of a gated-doppler current profiler system during 1979. Initial field tests have identified a number of design improvements which should be completed early in 1980. Other projects undertaken during the past year include modifications to the fluormetry data acquisition system, modifications to the PHAS (Hydrographic data acquisition system) system, and the building of a microprocessor development system and PROM programmer based on an HP 2645 terminal linked to the UNIVAC 1106. A further major effort has gone into the contracting and management of studies to examine methods of detecting pingo-like-features in the Beaufort Sea. These studies which are being financed by HARP (High Arctic Research Program) funds are being conducted in close cooperation with Field Hydrography.

Technical Support Group

During 1979 the Technical Support Group provided equipment maintenance, preparations, installations and field support to the West Coast Survey (*Parizeau*), Mackenzie River Survey (*Radium Express*), a number of smaller coastal surveys (*Richardson*) and shore parties at Vancouver, Pitt Lake and Harrison Lake. The commissioning of the barge *Pender* necessitated the installation of an SSB and VHF radio station.

New field equipment acquired in 1979 and injected into the maintenance program included two Ross portable survey depth sounders, one Simrad depth sounder, one MRS III positioning system, one communications and paging system, four portable radio transceivers, and a shipboard Communal Aerial System to supply AM, FM and TV reception throughout a ship.

The group was involved in various equipment trials which evaluated a number of launch echo sounders, a shipboard correlation echo sounder processor (CESP III) and a new model of a large, shipboard echo sounder recorder. Other projects undertaken this past year included working with field hydrography to overcome aeration and propeller noise interference problems with echo sounder installations in high speed launches and on the modification of two HF radio transceivers to enable the units to drive and control a single linear amplifier. Considerable effort in assisting the navigation group of field hydrography saw the eventual successful integration of the rho-rho Loran-C system with the dual-channel, transit satellite navigation system in the BIONAV configuration.

MECHANICAL ENGINEERING

G.R. Smith - Project Engineer

A.E. Moody
J. Steeples - Head, Mechanical Support

Along with his Industrial Liaison and contract supervision activities Mr. Smith has continued to provide general supervision of the Mechanical shops and Mechanical Engineering services. With the assistance of Mr. D. Redman, an engineering technician/draftsman whose time is shared with Ship Division, the group has effectively handled the routine design work associated with numerous minor projects.

The Mechanical Support Group which provides shops facilities and assistance to users in addition to meeting requests for shops services, had a very active 1979. All sections of IOS were making use of the machining and fabricating facilities and accordingly a high level of direct dupport and provision of advice and assistance was required. Many projects, which varied from repairs and modifications to the design and construction of prototype devices, were undertaken.

Projects were at times completed with the able participation of Ship Division's Depot Shops and with the utilization of a contractor who provided on-the-premises machining services to accommodate overload situations. Both the above techniques have proven highly successful in achieving good quality workmanship and in ensuring that all deadlines were met.

As an indication of the type of work undertaken during 1979 the following is a sampling of the variety of projects completed: pressure cases for equipment (Ocean Mixing, Coastal Zone Oceanography), salinity syphoning device (Frozen Sea Research), protective cage for a transducer (Coastal Zone Oceanography), Geiger counter sense head (Ocean Chemistry), XCTD modification to permit water tunnel tests (Offshore Oceanography), hydraulic housing for *Pisces IV* (Ship Division), milling of print bars (Computing Services) and the usual array of special purpose brackets, panels, plates and such items for all sections of IOS.

INDUSTRIAL LIAISON AND CONTRACTING

G.R. Smith

The Make-or-Buy policy and the DSS Unsolicited Proposal scheme have been positive steps towards promoting a research and development capability in the Canadian private sector. In spite of these policies, the overall level of Research and Development in Canada has not changed significantly. In addition, the effects of continued financial restraint are beginning to show. There has been a reduction in the level of contracting by departments, and the competition for unsolicited proposal funding has increased considerably. Although the level of funding for unsolicited proposals has increased steadily, so has the number of proposals received. At present, requests for funding are more than double available funds. Even though the overall picture does not look encouraging, those companies who have taken the initiative in preparing proposals that ultimately result in marketable products and services have done well.

At the Institute of Ocean Sciences, an active contract program is still in effect, but the large increases seen in previous years did not take place in 1979/80. It is unreasonable to expect these increases to continue unless major new programs are funded. However it is anticipated that the present levels of contracting will be maintained in 1980/81 if Institute funds are not further reduced.

For companies involved in marine sciences, 1979/80 has been a year of continued expansion in both personnel and markets. Most companies have reduced their dependence on government contracting and several are now involved in international markets. This rapid expansion now makes the need for a Marine Technology Centre adjacent to the Institute more obvious. This centre is expected to provide a focal point for marine sciences on the west coast and attract an increased volume of business. The concept of a Marine Technology Centre is not new, but in 1979/80, the Provincial Government gave its support to the development. As a result, the British Columbia Development Corporation was invited to undertake the project and a lease agreement for the property was finalized. The first phase of construction will be completed in 1980 and is expected to be fully occupied shortly after completion. Construction of further phases will be governed by the demand for space.

OCEANOGRAPHIC DIVISIONS

OCEAN PHYSICS DIVISION

*P.W. Nasmyth - Chief of Division

*Retired during 1979

The programs of the Ocean Physics Division are mostly directed towards three main objectives: improving the knowledge and understanding of the oceanography of the waters near the B.C. Coast, improving the knowledge and understanding of oceanographic processes important in the Canadian Arctic, and contributing to the understanding of the ways in which the oceans interact with the atmosphere on the scales relevant to climate. Using the expertise gained from their work in these areas, scientists from the Division are frequently called upon to advise local, national and international bodies on matters of direct practical concern, such as the environmental risk associated with an Arctic tanker port or the possible fate of waste material dumped at a particular location. This year major efforts were made in the First GARP Global Experiment (designed to obtain the first complete description of the behaviour of the world's atmosphere over the annual cycle), and in the Coastal Ocean Dynamics Experiment intended to improve understanding of water movements on the continental shelf west of Vancouver Island. However much other work was also accomplished as may be seen from the following pages.

FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

R.A. Cooke
*P. Johnston
A.W. Koppel
R.A. Lake
J.M. McNeill
*H. Melling
R.G. Perkin
D.L. Richards
*B. Smiley
R.B. Sudar
D.R. Topham
A. Wharton - Computing Services

*Joined in 1979

During 1979 the Frozen Sea Research Group (FSRG) made field trips

concerned with the oceanography of Bridport Inlet on the southern shore of Melville Island; tested measurement techniques used to determine the heat flow from polynyas (areas of open water within growing sea ice); joined with other agencies in acquiring field data aimed at the development of a computer model for sea ice motion in the Beaufort Sea near shore and acquired data from the sill of a polluted Greenland fjord from instruments deployed in 1978. Work was also carried out on the physics of underwater oil well blowouts; on instrument development, in particular a "salinity sucker" a device for looking for ice crystals in water; and on the new "Practical Salinity Scale 1978".

A study of physical oceanography in Bridport Inlet (Melville Island), initiated in 1978, continued through 1979. Bridport Inlet is the proposed northern terminal for the Arctic Pilot Project whereby liquid natural gas would be transported from the gas fields of the Sverdrup Basin to southern markets year round. In early March the tracked vehicles and sleds forming the logistic base for winter operations were moved from Resolute Bay to Rae Point by C-130 transport aircraft and then were driven for four days along the shoreline of Melville Island to Bridport Inlet. During the remainder of March, 61 CTD casts were taken, six Aanderaa recording current meters were deployed to await summer recovery, one tide gauge deployed in August 1979 was recovered and two more gauges were deployed. In addition an ultrasonic current meter was used in conjunction with a prototype conductivity-temperature (CT) chain to investigate internal waves within the inlet. Operations were made difficult by high winds (40-50 knots) coupled with low temperatures ($-30^{o}C$ to $-45^{o}C$). Water structure showed a marked difference between water inside and outside the inlet. The recording current meters which provided a record of 100-125 days' duration showed complex currents at the inlet entrance. Within the inlet significant currents were sustained only during runoff in late July. Internal waves were evident on CTD profiles and well-defined internal wave packets were recorded by the ultrasonic current meter and CT chain. Work was initiated with the modelling group at the Institute to model residual flow within Bridport Inlet. Further field work is planned.

The second stage of the Polynya Project, intended to test measurement techniques, was enacted. A combined team comprising members of FSRG, AES and BIO established camps on Dundas Island, N.W.T., to make preliminary measurements of heat flux from an area of open water under conditions of extreme temperature difference. Unfortunately conditions were far from ideal, the only open water consisting of two adjacent patches approximately 200 metres across, bordered by a large rubble field. These open areas were short lived, freezing over before the measurements could be completed.

FSRG completed operational flight trials of the radio controlled model aircraft and gathered temperature data over both solid ice and open water. In general the aircraft and its data telemetry system performed satisfactorily under arctic conditions, but development has continued during the summer with the addition of on-board positioning equipment accurate to ± 2 metres based on the Decca Mini-fix system, and an improved control system.

Mean air temperature profiles were obtained from a 4 metre mast which suggest that, over fetches of up to 60 metres, the major temperature drop takes place within a distance less than one metre from the water surface. Moored current meters in the vicinity of the polynya indicated that over a 10-day period, the tidal flows from the north, that is from areas of thin or

broken ice, were consistently cooler than flows from the south, the direction of unbroken ice cover.

Unfortunately neither the AES nor BIO parties were able to obtain data over open water since the open areas closed early in the trip, but both achieved full tests of their equipment under operational conditions and on the over-ice atmospheric boundary layer.

In the second half of 1979, we became involved in the Beaufort Sea Winter Ice Experiment, a joint government/industry study aimed at the development of a computer model to predict the motion of sea ice. Such prediction requires an understanding of the combined effects of winds, ocean currents, the rotation of the earth and the strength of ice on the ultimate speed and direction of ice drift. To provide data to test the models being developed, a co-ordinated observation program of the ice, ocean and atmosphere over an area of 100,000 square kilometres in the southeastern Beaufort Sea was conducted in November and December 1979. We carried out a survey of ocean temperature and salinity over the area to a depth of 400 metres. These measurements will be used to calculate the steady current at the surface of the ocean and its effect on ice movement. Due to unusually mild weather, which resulted in relatively thin ice for the season, and to the limited amount of daylight with encroaching polar winter, most of the measurement sites were visited using a helicopter equipped for instrument flying and capable of keeping its full weight off the ice while stationary. Several more distant sites (up to 400 km offshore) were visited using a ski-equipped aircraft. The survey was successfully completed in six days. Analysis of the data acquired, and FSRG participation in computer development, will continue into 1980.

Acquisition of oceanographic data through the sea ice in late November 1979 about 300 km north of the Beaufort Sea coast. Special care had to be taken to put this Twin Otter aircraft down on the thin ice existing at that time of year and it was preceded by a Cessna 185 that could safely land on much thinner ice and radio back the measured thickness to the Otter pilot. The observers are recovering the conductivity-temperature depth probe after it had been lowered using the small portable winch shown.

Mine tailings were being dumped into Agfaidikavsa Fjord in Greenland with the expectation that the sill at the head of this small fjord would retain the sediments. However, the pollutants were escaping and a current meter installed on the sill to monitor conditions showed that relatively high currents could occur during "events" resulting from denser water spilling over the sill. This displaces the polluted water in the small fjord raising it over the level of the sill so that it can pass in Quamarajuk Fjord. Analysis of this data is continuing. The mine has recently improved its process to remove most of the dangerous metals from the effluent.

The laboratory studies of gas hydrate formation and out-gassing of oil drops were completed under a contract let to the University of Calgary. The vertical flow, high pressure water tunnel designed and built in 1978 was successfully operated at pressures up to 1300 psi and the behaviour of hydrocarbon gas bubbles were studied under conditions of both constant pressure and simulated rise (decreasing pressure) over a range 1300 psi. The formation of gas hydrates was demonstrated under a variety of conditions which suggests that, in a blowout occuring at depths greater than 500 metres, all the gas would be converted to solid hydrate. Experiments on the decompression of gas saturated oil drops showed that in the absence of hydrate particles the dissolved gas diffused directly into the water column. With hydrate particles present in the water column, the oil drops became coated with hydrate which decomposed under simulated rise conditions. At no time did out-gassing result in fragmentation of the oil drops.

A further contract has been let to elucidate some features of the present results, in particular, the role played by background dissolved gas in controlling the induction time of the formation process.

An issue of interest to arctic oceanographers for many years is the apparent super-cooling of waters beneath growing sea ice. A "salinity sucker" has been constructed which is capable of measuring the conductivity and temperature of the water pumped past these sensors while collecting entrained ice crystals on a filter. Super-cooling is relieved by the passage of the water through the filter and the amount of ice can be measured *in situ* by melting the ice in a closed chamber and measuring the resulting change in salinity. This information will further the understanding of ice formation and growth as it occurs in nature, and will also provide a means of ascertaining the heat balance in the water of polynya and thereby supplement the atmospheric measurements.

Salinity, or the fraction by weight of salt dissolved in seawater, is a quantity in everyday use by oceanographers. However there are serious problems in present definitions making the uncertainty in inter-institutional comparisons considerably greater than the precision of the measurement. In response to the need for a universally accepted method of calculating salinity, the Joint Panel on Oceanographic Tables and Standards generated a new and more accurate data set based on our recommendation for the "Practical Salinity Scale 1978". We had the task of providing the definition and fitting these data to a set of empirical equations valid over the entire oceanographic range of variables. This was done and the equations and the definition of salinity were accepted by the IAPSO at the IUGG meeting in Canberra in December 1979.

Giving environmental advice to committees concerned with arctic industrial development has now become a major task which requires about two person/years annually. The Arctic Water Advisory Committee probably gives the most work of the eight in which we presently participate.

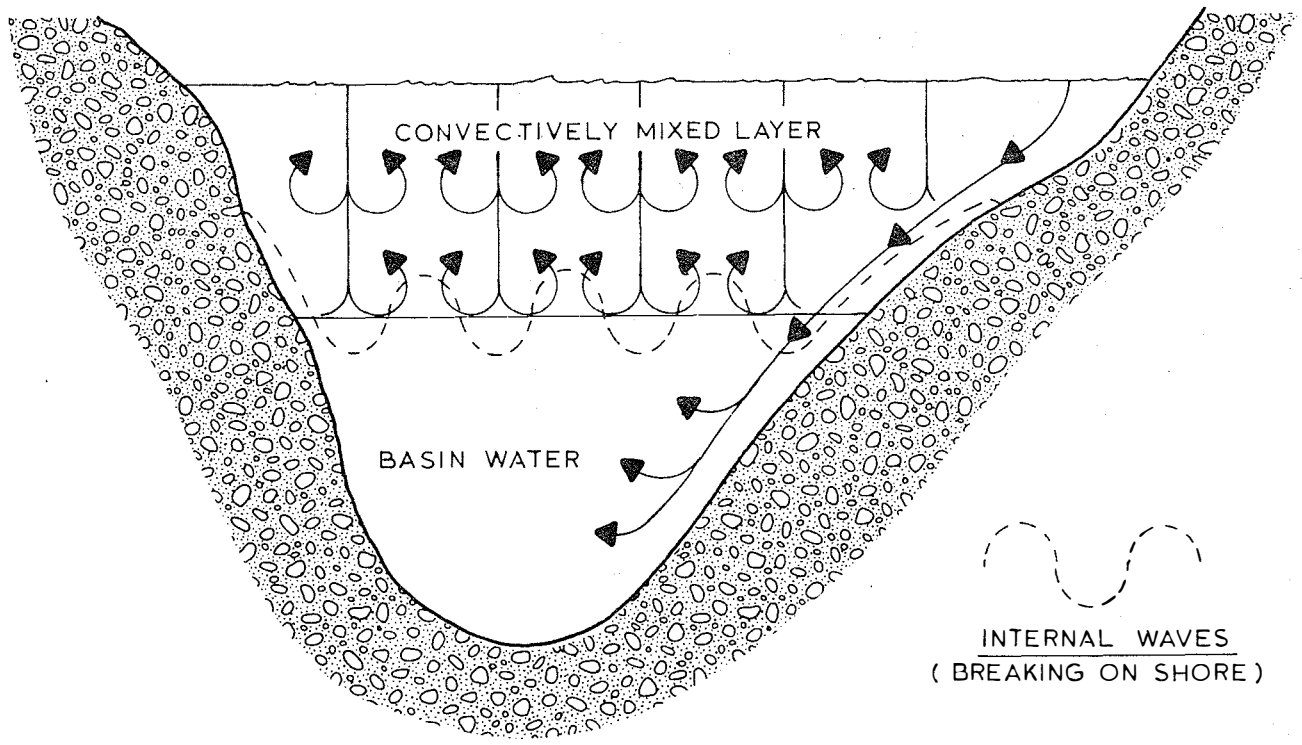


Figure 1. Sea ice is far less salty than the water from which it grows and the remaining salt is rejected at the freezing interface. This produces a vertical convective circulation which penetrates downwards to a depth depending on the water density structure to produce a two-layer system, as shown in this schematic. A typical depth of the convectively mixed layer might be 50 metres and, where the water is shallow, the mixing process is not complete before the cold, dense brine rejected by the ice hits bottom and flows down the slope. This process has been observed in bays, and it is very probable that it occurs on a much larger scale in the Arctic Ocean as a whole, which has shelf seas of area about twice that of the basin. It has been noted that currents of dense water along the bottom are often mixed in by breaking internal waves, a point made schematically in the figure.

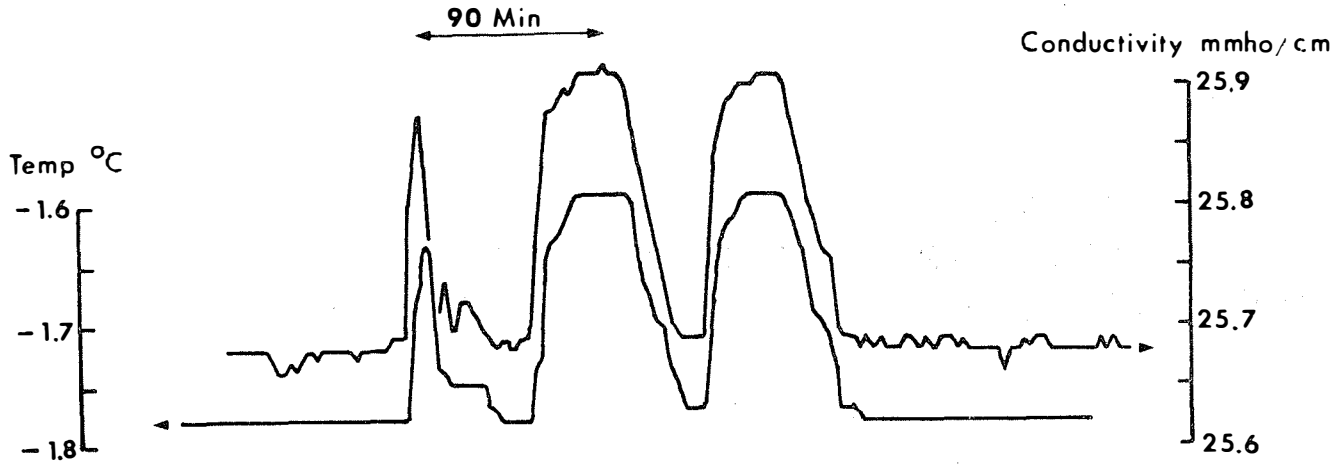


Figure 2 shows such a wave pattern, as described in figure 1, on the interface between the mixed layer and basin water at Bridport Inlet, as recorded by our "salinity chain".

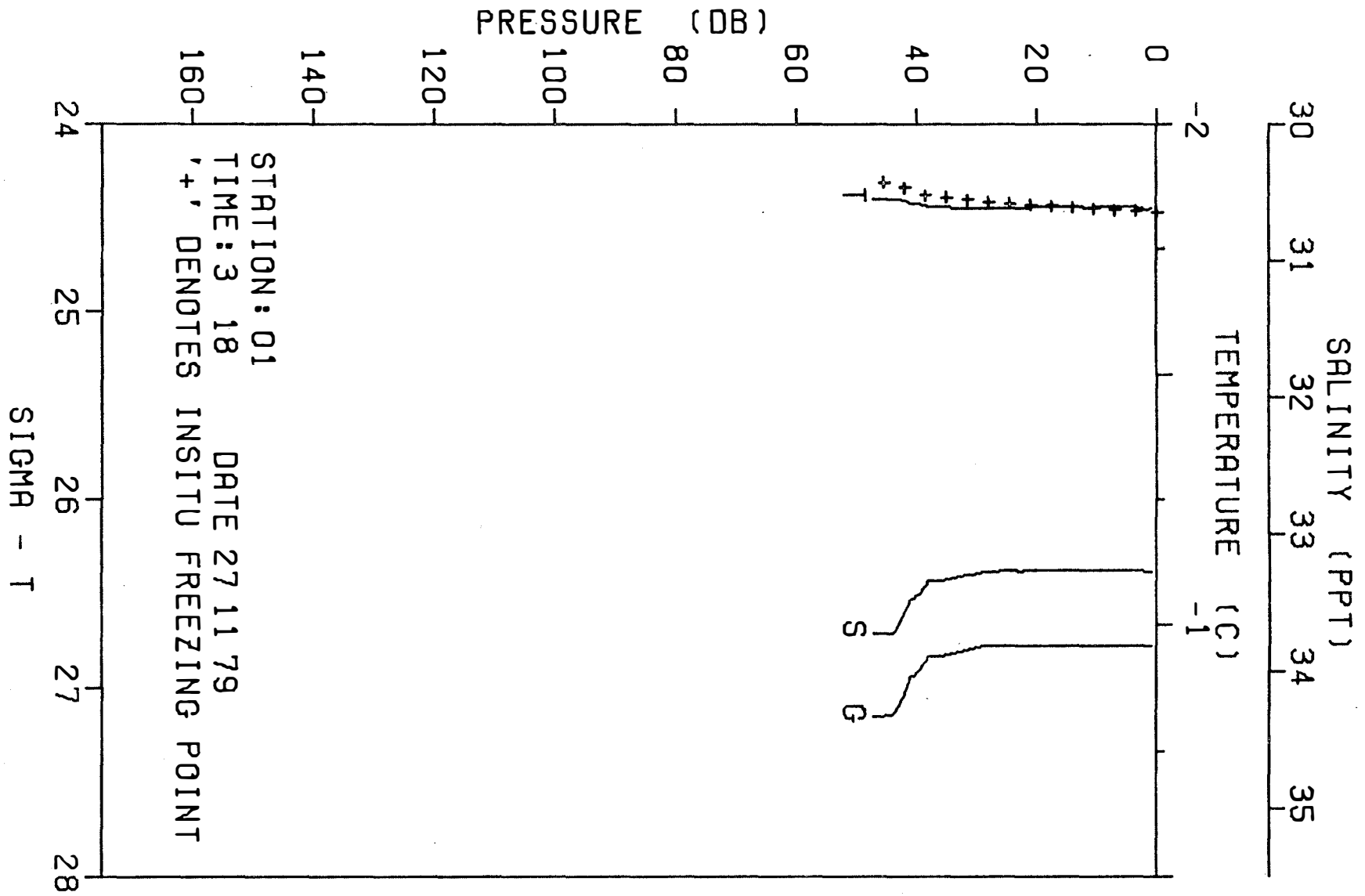


Figure 3 shows cold saline water on the bottom at a location about 100 km north of the Beaufort Sea coast at a depth of 48 m water. The sea is nearly at the freezing point (marked with crosses on the figure) from top to bottom but shows a sudden increase in salinity and, hence, in density, in the last 8 m.

COASTAL ZONE OCEANOGRAPHY

D.M. Farmer - Head

W.H. Bell
R.H. Bigham
H.J. Freeland
L. Giovando
G. Kamitakahara
A.P. Lee
J.H. Meikle
D.G. Sieberg
L.A. Spearing
J.A. Stickland
D.J. Stucchi
*Z.W. Xia

*Joined in 1979

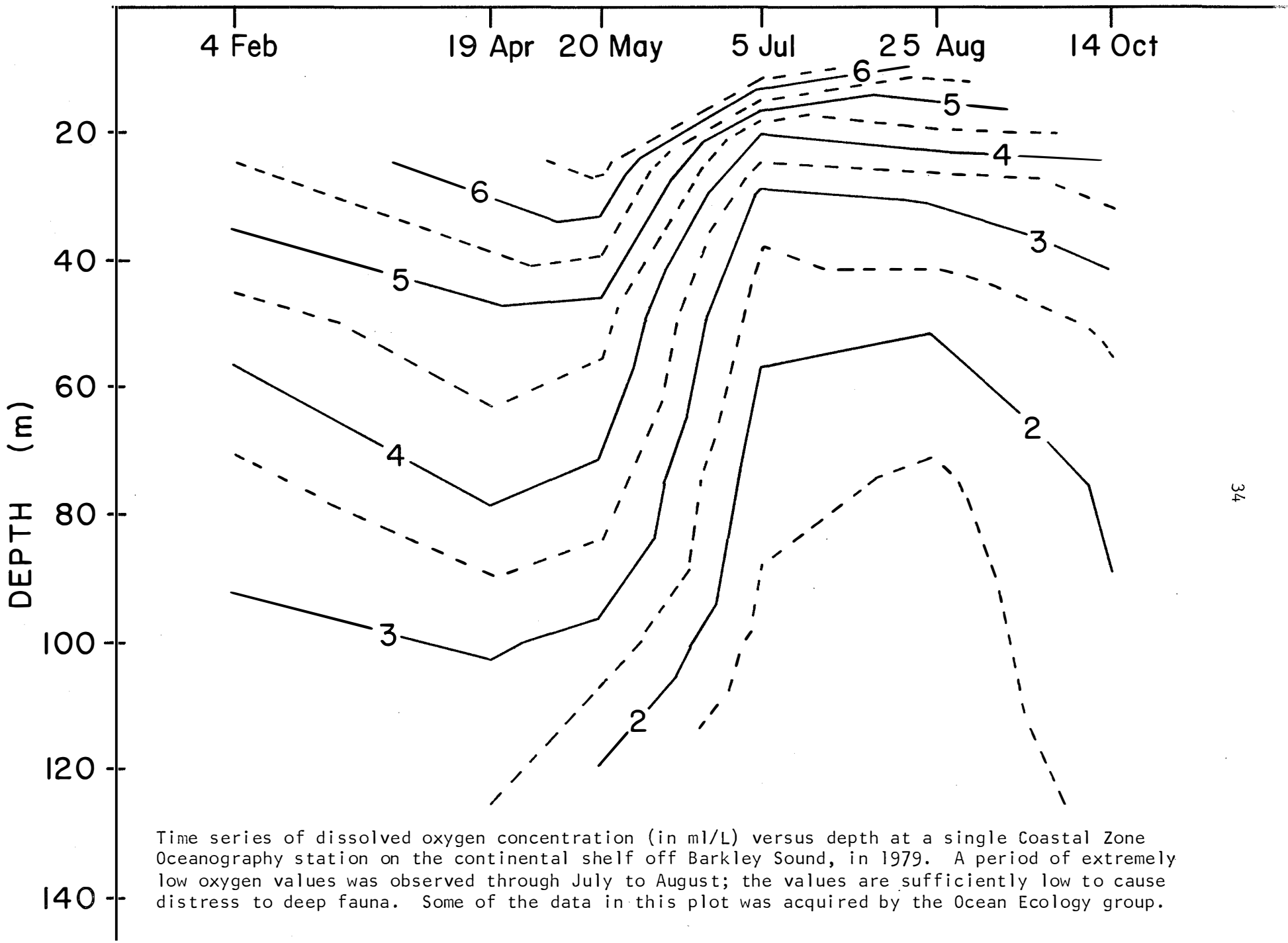
This year Coastal Zone embarked on a major field operation on the continental shelf as part of the Institute's Coastal Ocean Dynamics Experiment (CODE). A line of current meter moorings formed the southernmost of the experimental arrays, and initial data from these look promising. The dynamics of shelf waters critically influence the flushing of deep estuaries and we have taken the unique opportunity provided by the experimental work on the shelf to study exchanges with Alberni Inlet. Early data from this project also look promising.

A workshop on Fjord Oceanography, funded by the NATO Advanced Studies Institute, was hosted at the Institute. One hundred and two scientists from 10 different countries attended with interests in the physics, chemistry and biology of fjords.

Continental Shelf Project

This is the first year of a major effort by Coastal Zone Oceanography to study some aspects of the circulation on the continental shelf and slope west of Vancouver Island. During 1979 Coastal Zone sent a total of seven cruises to the shelf on this project.

In April 1979 four current meter moorings, and one anemometer buoy, were deployed along a line perpendicular to the shelf break and just south of Barkley Sound. All moorings had sub-surface buoyancy, and carried Aanderaa current meters. Unfortunately, a short time before scheduled recovery, two of our moorings were hit by mid-water trawling vessels and were dragged a considerable distance. Despite this, current meters were recovered from the affected moorings, and the data return from the entire deployment is actually quite good; 6½ complete records, out of a total of 10 deployed, have been returned. Furthermore, data are available from every mooring for almost the entire period of deployment. The mooring array was recovered in early October, and the entire array has been redeployed. We hope to maintain the array until May 1981, so that two complete seasonal cycles will have been observed. Current meter processing has just begun (as of writing) and it is too early to come to any significant conclusions.



Time series of dissolved oxygen concentration (in ml/L) versus depth at a single Coastal Zone Oceanography station on the continental shelf off Barkley Sound, in 1979. A period of extremely low oxygen values was observed through July to August; the values are sufficiently low to cause distress to deep fauna. Some of the data in this plot was acquired by the Ocean Ecology group.

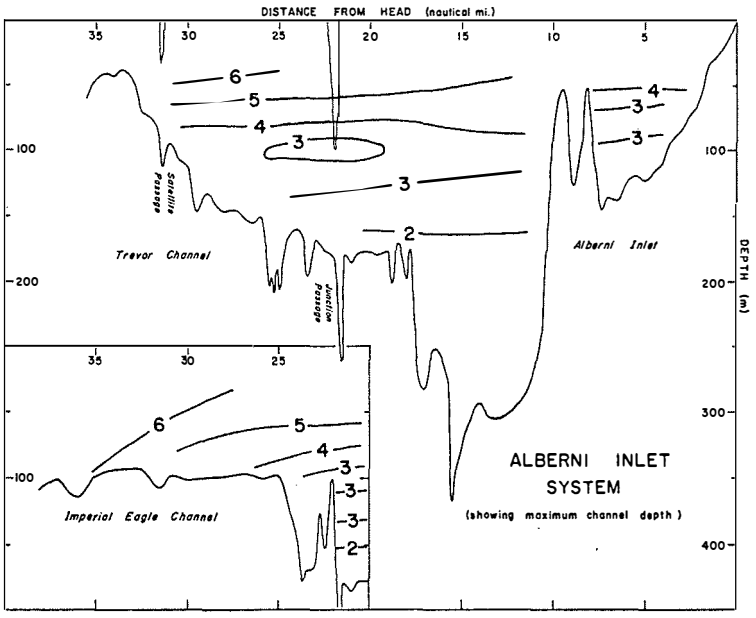
Temperature, salinity and dissolved oxygen concentrations were measured on each cruise, and the results have been surprising. During a two to three month period in mid-summer, 1979, a water mass encroached on the shelf which was distinguished by high density and very low oxygen concentration. The oxygen is low enough to cause serious distress to bottom living and deep swimming marine animals. (The oxygen concentration values were below one ml/L at the bottom.) It remains to be seen whether or not this is an annual phenomenon. A preliminary analysis suggests that this water mass could not have come directly from offshore, for several reasons, and so we conclude that alongshore drift, or advection, must be responsible. The test of that hypothesis must await detailed analysis of the current meter records.

The shelf project is being run in close collaboration with the project in Alberni Inlet described below. It is hoped that the study on the continental shelf will help identify the sources of water that are involved in the deep-water renewal events in Alberni Inlet.

Alberni Inlet Circulation Study

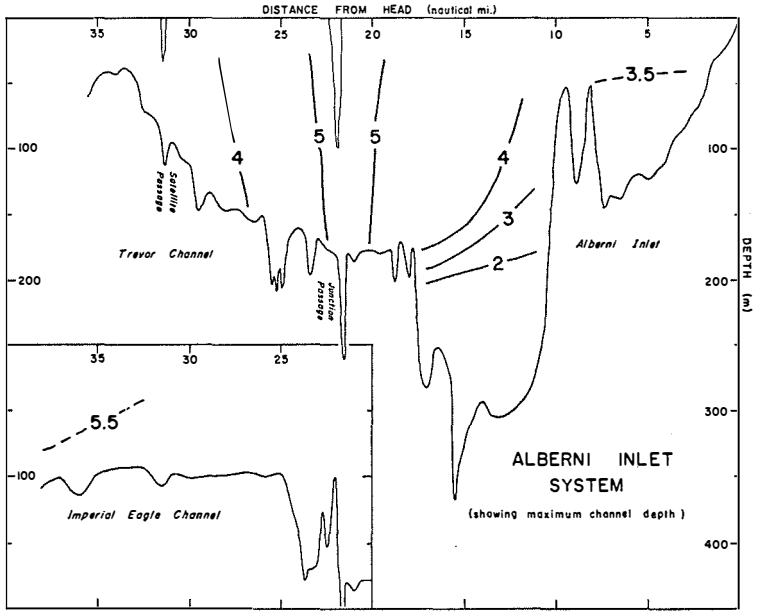
An investigation of some oceanographic features of the Alberni Inlet - Barkley Sound fjord system was begun in 1979. In particular, it is intended to study the deep water circulation, including the inter-relationship with upwelling on the continental shelf. Data are being gathered with two moored instrument arrays, one in each major basin of Alberni Inlet. The instruments are recording current speed and direction, water temperature and salinity at half-hourly intervals at three depths. In addition, hydrographic cruises are being conducted, every five or six weeks, to obtain water structure profiles, including temperature, salinity and dissolved oxygen, at fifteen stations throughout the system. Similar data will be provided by the Continental Shelf Programme for the coastal waters adjacent to Barkley Sound, so that the influence of coastal phenomena on fjord circulation can be examined.

From a study of historical data for Alberni Inlet, available mainly for the inner basin, it seemed likely that shelf water played a major role in the fjord circulation, but principally during the late winter and spring months, when the deep water in the basin underwent an annual renewal. Then, it was thought, the system became relatively quiescent and diffusive processes played the dominant role in changing the deep water structure for the remainder of the year. It now appears that the quiescent period may be considerably shorter than previously suggested. The first cruise of the year, in late January, showed that some renewal of the deep basin water had already occurred, the dissolved oxygen values being much increased. As the upwelling season progressed through May and June, dense water appeared on the shelf, resulting in an additional substantial replacement of fjord water. (It remains to be shown whether the dense shelf water is the result of upwelling or advective processes.) The denser water, as it continued to flow into the fjord, decreased in oxygen content with time, so that dissolved oxygen levels in Alberni Inlet were gradually reduced by this mechanism. Subsequent cruises showed that shelf water was still exerting an influence on the whole Alberni Inlet system at least to the end of August. One result of a preliminary examination of the data has been to suggest that the system is very dynamic,



DISSOLVED OXYGEN
(ml/l)
8/3/79

Dissolved oxygen profiles obtained by Coastal Zone Oceanography in Alberni Inlet showing a typical structure (above, March) and an atypical structure (below, April) wherein it is evident that an influx of "new" water is underway through Junction Passage, with subsequent spreading in both directions along the Inlet,as evidenced by the high oxygen values centred on Junction Passage.



DISSOLVED OXYGEN
(ml/l)
18/4/79

with changes at the fjord mouth being advected throughout the system in no more than a few days.

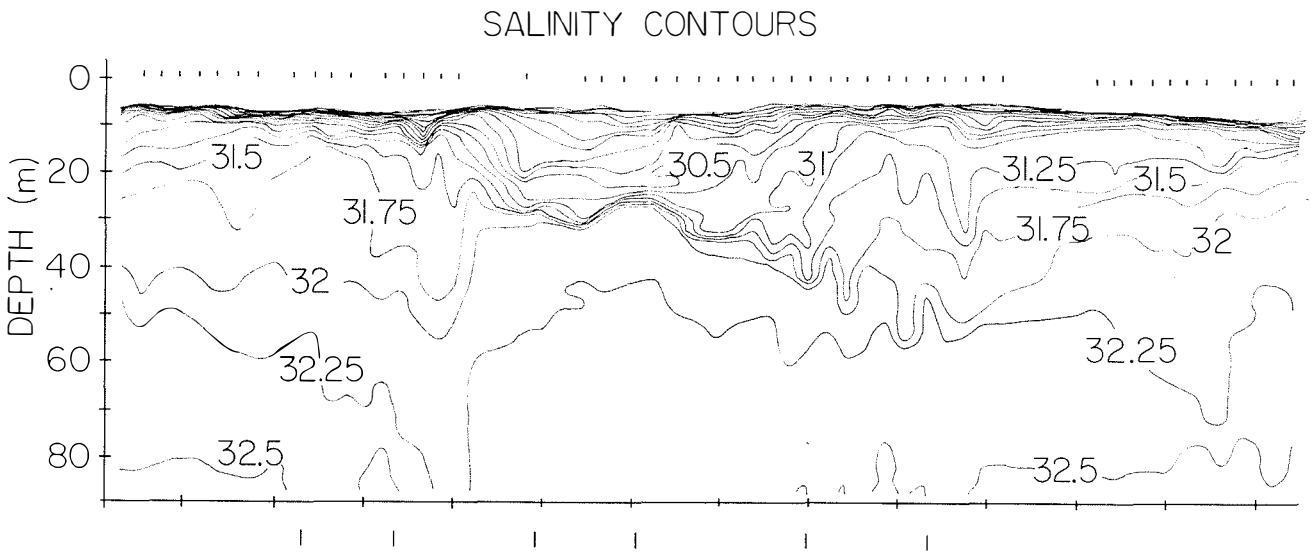
To date only one set of data from the moored instruments has been processed. The period covered by these data is from April to August at Junction Passage and from May to August at Sproat Narrows. The prominent feature in these data is the well-defined dense inflow period that occurred from May 20 to July 5 at both locations.

At Junction Passage the strongest inflow currents (30 cm/s) were recorded near the bottom (205 m) well below the 100 m sill level. Furthermore, the strong inflow current occurred in three bursts of four to five days duration. At mid-depth (145 m) the current speeds were lower and the burst-like character was not as well defined as that at 205 m. At both depths a tidal signal was evident but it was not of sufficient amplitude to stop the inflow. As expected, salinity (hence density) at both depths increased during this period.

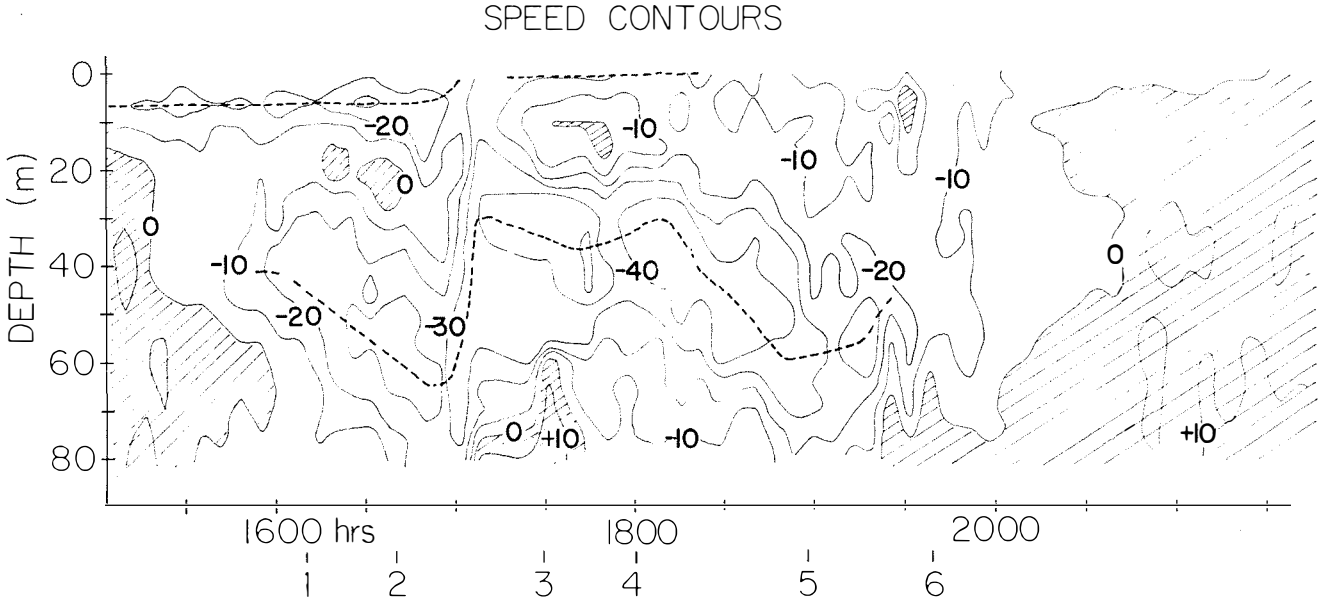
At the Sproat Narrows mooring the strongest (40 cm/s) currents were recorded near the bottom and, generally, the current speeds were larger than those recorded at the Junction Passage mooring. Unlike the Junction Passage data, the inflow currents here are half-wave rectified; strong inflow current during the flood tide, and negligible currents during the ebb tide. The salinity data does not consistently increase during this period - this could be due to drift problems with a conductivity sensor. However, there is a clear tidal signal in the salinity data with high salinities coincident with strong flood current indicative of a density current similar to that seen in Rupert-Holbert Inlet.

The Dynamics of Flow over Sills

A two-week field program was undertaken in Knight Inlet as part of a study aimed at improving understanding of tidal interaction with a constriction and the way in which this influences circulation. It was found that under the right conditions, boundary layer separation at the crest of the sill can lead to a spreading mixing layer. This layer, which is often marked by well defined instabilities, achieves, a thickness of up to 50 m before collapsing. The formation of lee waves is closely linked to separation of the boundary layer, in much the same way as has recently been proposed for the atmospheric analogy of flow over mountains. Since the lee wave properties depend upon flow speed, a critical speed can occur at which the lee waves are able to suppress the separation. However, an important distinction in the case of tidal flow over sills is the acceleration of the current, which may be responsible for a strong asymmetry in the lee wave response that we have observed in Knight Inlet.



Contours of constant salinity (above) and along-channel velocity component (below) derived from profiles taken by Coastal Zone Oceanography, 300 m downstream of the sill in Knight Inlet during an ebb tide. The dashed line in the lower figure shows the location of the strong jet, which can change abruptly as lee waves escape upstream from the sill. Shaded areas correspond to reverse flow, toward the sill.



Lighthouse Program, Task Force Studies and Saanich Inlet Program

The program for collection of daily sea-water samples from B.C. light stations continued, together with preparation of 1977 and 1978 data for publication. Advice was given on oceanographic aspects of various environmental problems including the proposed expansion of the Roberts Bank Terminal and modifications to the Sechelt Sewage System. Further editing was carried out on a Beaufort Sea report concerned with factors affecting pollutant dispersal.

Analysis of water properties in Saanich Inlet is providing further information on the flushing of this partly anoxic body of water. The dissolved oxygen contribution for 1978 indicates that below 100 m the water was not renewed in August/September as has generally occurred in other years. Apparently some renewal occurred between sill depth (80 m) and 150 m during July and November (1978). At sill depth during late 1978 there were net southerly flows (i.e. into the inlet) at monthly intervals, lasting about six days in each case.

Miscellaneous

Watching briefs were continued on developments in both mooring technology and ocean dumping technology. Development of a three-dimensional static sub-surface mooring model, as an aid in examining oceanographic data obtained from moored instruments, was completed. Assistance with mooring problems was provided to other groups in the Institute. A fourth review of an annual series of papers relation to the physics of ocean dumping was produced.

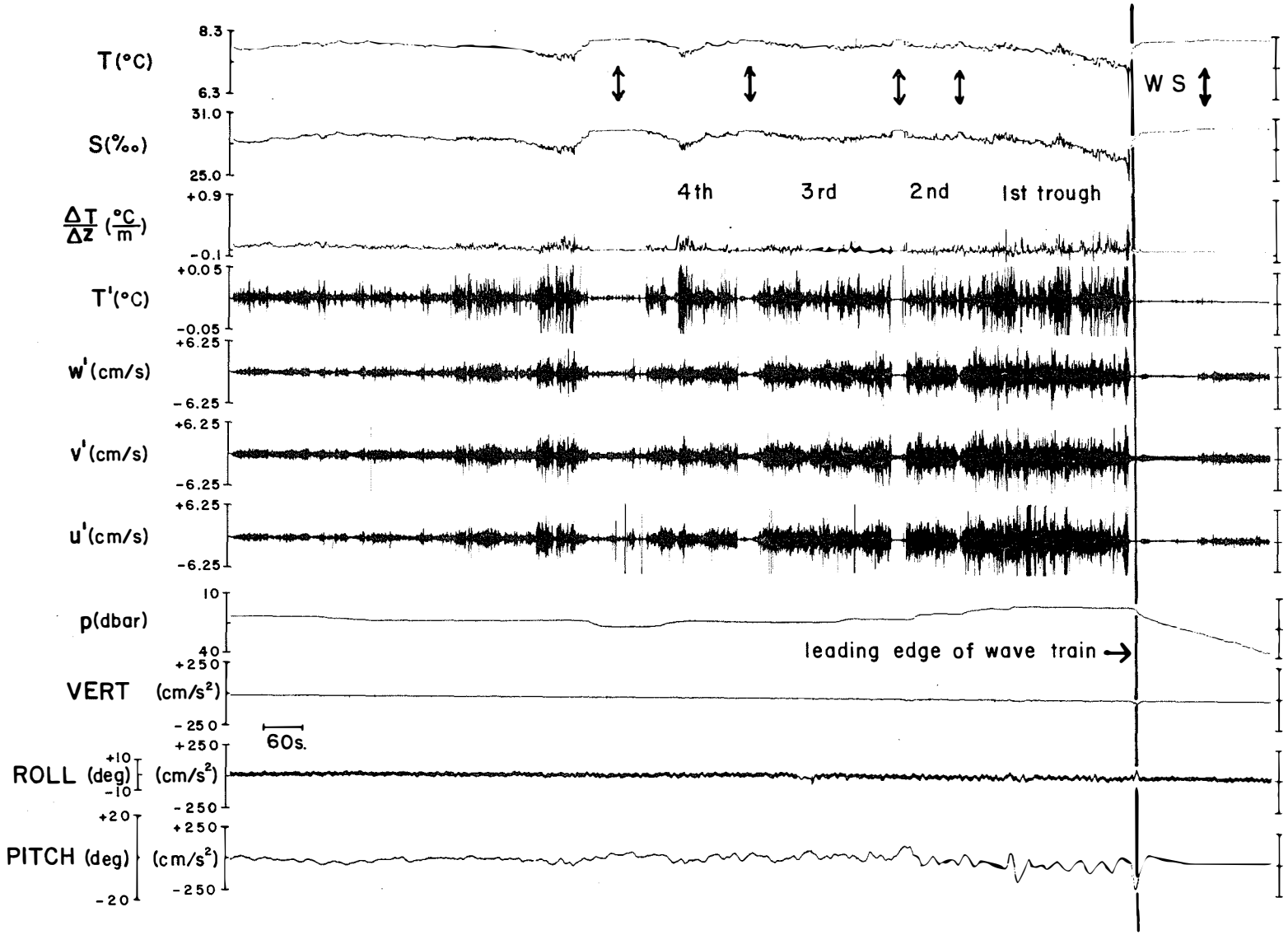
OCEAN MIXING SECTION

A.E. Gargett
*P.W. Nasmyth
G. Chase
R. Teichrob

*Left in 1979

The Ocean Mixing Group was incorporated into Offshore Oceanography during 1979, following the retirement of group head, Dr. P. Nasmyth; we shall miss Pat's smooth handling of our affairs and his cool head in times of crisis.

Considerable effort in 1979 went towards instrument calibration facilities. A calibrator built to fit the IOS water tunnel allows complete angle-of-attack calibrations of the small ducted rotor current meters used to measure forward speed and cross-flows on the *Pisces IV* submersible. Since the sensitivities of all high-frequency turbulence sensors are functions of mean flow speed, this is a particularly important measurement. A plume tank for calibration of the platinum film probes used for high frequency temperature measurements is near completion.



Records from *Pisces*-mounted turbulence package as the submersible passes through a train of highly turbulent internal waves. As *Pisces IV* travels from the rear (left) to the front of the wave train, the probes encounter warmer and saltier water (WS, marked by arrows) where internal wave crests lift the deeper water of the inlet up to the level of the submersible. Turbulent velocity (u', v', and w') and temperature (T') fluctuations are absent from these regions. Very strong downwelling velocities in front of the waves drive the submersible steadily deeper in the water column as soon as it passes through the leading edge of the wave train.

We are presently analysing the data obtained in Knight Inlet with the submersible-mounted turbulence package. Records from passage of *Pisces IV* through a highly turbulent train of non-linear internal waves are shown in the figure. As *Pisces IV* travels from the rear (left) to the front of the wave train, the probes encounter warmer and saltier water (WS, marked by arrows in the figure) where internal wave crests lift the deeper water of the inlet up to the level of the submersible: turbulent velocity (u', v' and w') and temperature (T') in front of the waves drive the submersible steadily deeper in the water column as soon as it passes through the leading edge of the wave train.

OFFSHORE OCEANOGRAPHY

*B.W. Canning
C. De Jong
**J.F. Garrett
P.M. Kimber
J.S.C. Kuwahara
J. Linguanti (Computing Services)
J. Love
B.G. Minkley
M. Miyake
*J. Papadakis
**S. Tabata
**R.E. Thomson

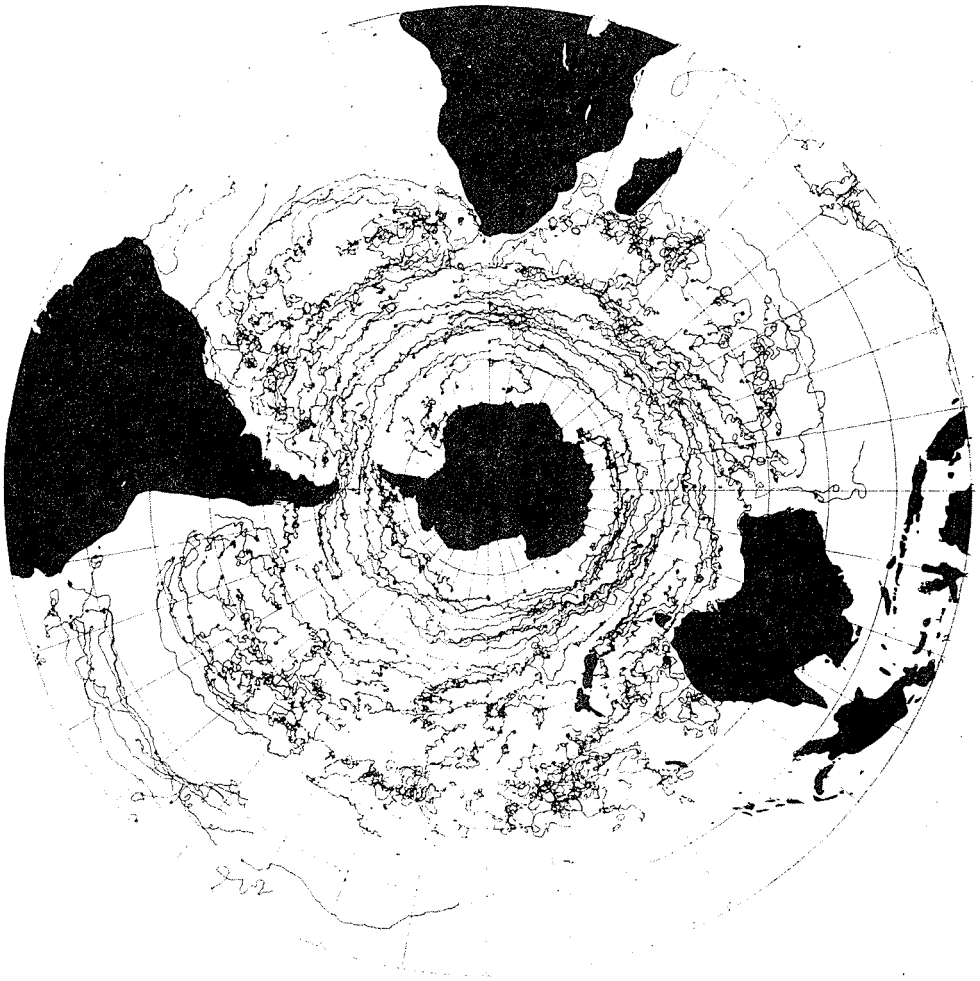
*Joined during 1979
**Served as Section Head during part of 1979

During 1979 a major part of the efforts of the Offshore Oceanography Section was devoted to the First GARP Global Experiment. However this did not prevent significant participation in a new measurement programme on the continental shelf or of continuation of activities related to the weathership programme and North Pacific oceanography.

FGGE Drifting Buoy System

Years of planning and preliminary work finally paid off with the successful implementation and operation of the Drifting Buoy System for the First GARP Global Experiment, (FGGE). The first of a total of 368 buoys was deployed in October 1978, while more than 200 were still working on November 30, 1979, the official end of the FGGE Observational Year. Most of the buoys were deployed in the southern hemisphere but there were also a number in the Arctic and in equatorial waters. The data from these buoys, which measured barometric pressure and sea surface temperature, were collected by the Argos system carried on the TIROS-N and NOAA-A satellites. This system also permitted determination of the position of each buoy several times daily, with an accuracy of about one kilometre.

The information recorded on the satellite was transmitted to one of several ground stations, which in turn relayed it to the Service Argos computer centre in Toulouse, France. There, the raw data were transformed into meteorological variables, and the buoy positions calculated. The resulting information was disseminated over the meteorological Global Telecommunications System, as well as being saved for future research use.



Tracks of drifting buoys deployed in the Southern Hemisphere during the FGGE Operational Year (December 1, 1978 - November 30, 1979). These buoys reported measurements of barometric pressure and sea surface temperature by means of the Argos Satellite and Data Collection System.

Preliminary results from the meteorological agencies using the buoy data indicate a need for significant revision of previous ideas on the severity and origins of high latitude storms. Several agencies reported a marked improvement in their ability to provide weather forecasts during the period the buoy data was available.

Canada, and IOS in particular, played an important part in the planning and implementation of this array. A prototype experiment conducted with Canadian buoys showed that the project was feasible. The complex plan for deployment of the buoy array using volunteer ships was developed by Dr. Noel Boston of Beak Consultants under contract to IOS. Canada contributed 74 buoys to the array. Dr. Garrett of IOS served as chairman of the Buoy Participants Committee which organized the project throughout its life. He also managed the Buoy Control Centre in Toulouse, which provided liaison between the buoy participants and the operators of the data collection system as well as the processing and quality control of the data stored for research use.

Coastal Oceanic Dynamics Experiment (CODE) (In conjunction with Tides and Currents, Ocean Ecology and Coastal Zone Oceanography Sections.)

Field operations for a major study of the oceanography off the west coast of Vancouver Island began in May with a three-week cruise on board the CSS *Parizeau*. Current meters were deployed on lines of moorings off Estevan Point and Brooks Peninsula, extending from the continental shelf to water depths of 2500 m roughly 150 km offshore, and at the entrance to Juan de Fuca Strait. Deep-sea and coastal tide gauges and two offshore anemometers were also installed as part of the program. The horizontal and spatial distribution of water properties (temperature, salinity, dissolved oxygen) in the region of the moorings were obtained for a grid of CTD/Hydro stations.

The CTD/Hydro measurements were repeated with greater detail during a two-week cruise in August using the *Pandora II*, and again in September when all current meters were refurbished.

Data collected during the 16-month field programme will provide oceanographers of the Institute of Ocean Sciences with a detailed knowledge of the spatial and temporal variability of currents, water properties and phytoplankton off the west coast of Vancouver Island. Physical processes to be studied include the generation and propagation of continental shelf waves and internal tides, seasonal variability of coastal currents and water structure, and upwelling events.

Vancouver Harbour Currents (In conjunction with Tides and Currents Section)

The First Narrows forms a confined, shallow (30 m) channel connecting the outer basin of Burrard Inlet to the inner basin (Vancouver Harbour) of the inlet. The channel possesses intense tidal currents of up to 2.5 m/s and seasonally varying vertical density structure of relevance to navigation. Cruises were undertaken on the CSS *Vector* in April, June and December 1978, during which time grids of 25-hour time-series current/CTD stations were occupied at the east and west approaches to the Narrows. Using acoustic

current meter/CTD profiles in conjunction with a shore-based trisponder ship-positioning system and an automatic data acquisition recorder, we were able to obtain "snap-shots" of water properties and horizontal currents over the two small spatial grids at the approaches to the Narrows. Despite the shallow depths, the currents show evidence of pronounced vertical shear at certain stages of the tide; there is also considerable small-scale horizontal eddy structure that can be used to advantage by operators of small vessels when entering the Narrows.

Johnstone Strait - Internal Tides (In conjunction with Tides and Currents Section)

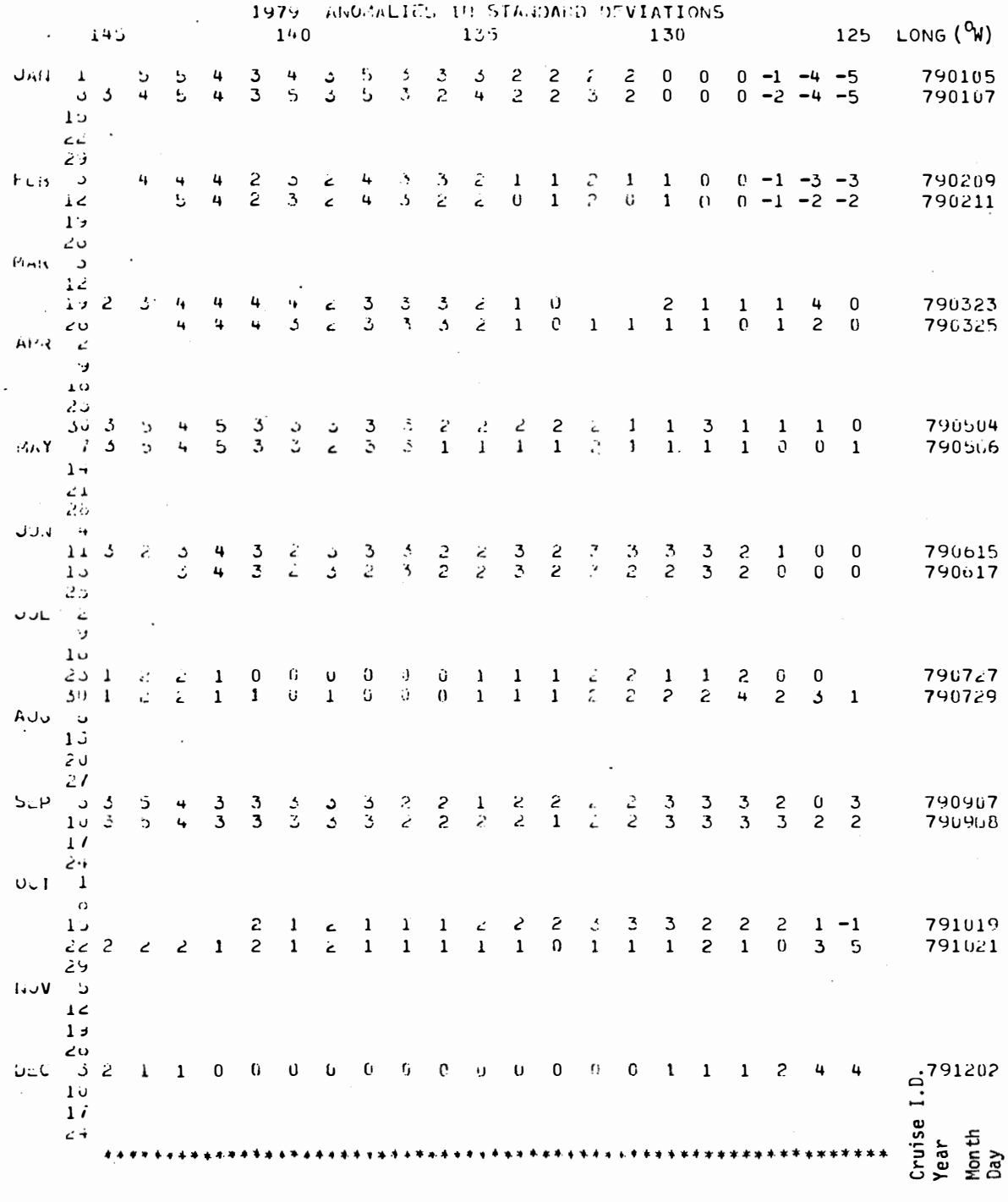
The western basin of Johnstone Strait is a narrow deep channel separating northeastern Vancouver Island from the mainland coast. An analysis of current and water property measurements taken in the channel in 1973 and 1976-1978 showed that it possesses an internal (baroclinic) tide of semi-diurnal period generated through interaction of the surface tide with the shallow sill at the eastern end of the basin. Near the generation region, the baroclinic tide produces currents of over 20 cm/s, or 50% of the baro-tropic tidal currents, but accounts for less than 0.5% of the power lost by the barotropic tide in the vicinity of the sill. The baroclinic tide is dominated by a first-vertical mode, seaward propagating internal Kelvin wave which undergoes attenuation over an e-folding distance of one wavelength (25 km). Turbulent frictional effects account for attenuation of both the barotropic and baroclinic M_2 tides in the channel.

Seiches, Juan de Fuca Strait

A preliminary investigation was started into the cause of barotropic seiches in the larger embayments and inlets along the Canadian side of Juan de Fuca Strait. Pressure gauges deployed in Pedder Bay near Victoria for a period of two months in early 1978 gave spectral peaks at 10 and 15 minutes, with amplitudes of around 10 cm maximum. Further measurements are planned with pressure gauges in Victoria Harbour, Pedder Bay, Becher Bay and Port San Juan along the coast of Juan de Fuca.

Sea-Surface Temperature Anomalies Along Line P

Over the past 20 years continuous sea-surface temperatures have been observed along Line P by the two Canadian weatherships enroute to and from Station P. These data have finally been processed, edited and statistics compiled. From the climatic means and the associated standard deviations anomalies have been estimated. An example of the anomalies estimated for each cruise data for each month of 1979 is shown in the accompanying table. It is evident that during the first nine months positive anomalies were present over most of the Line except for near the coast where negative anomalies occurred during the first two months. In December the positive anomalies disappeared along most of the Line except near the coast.



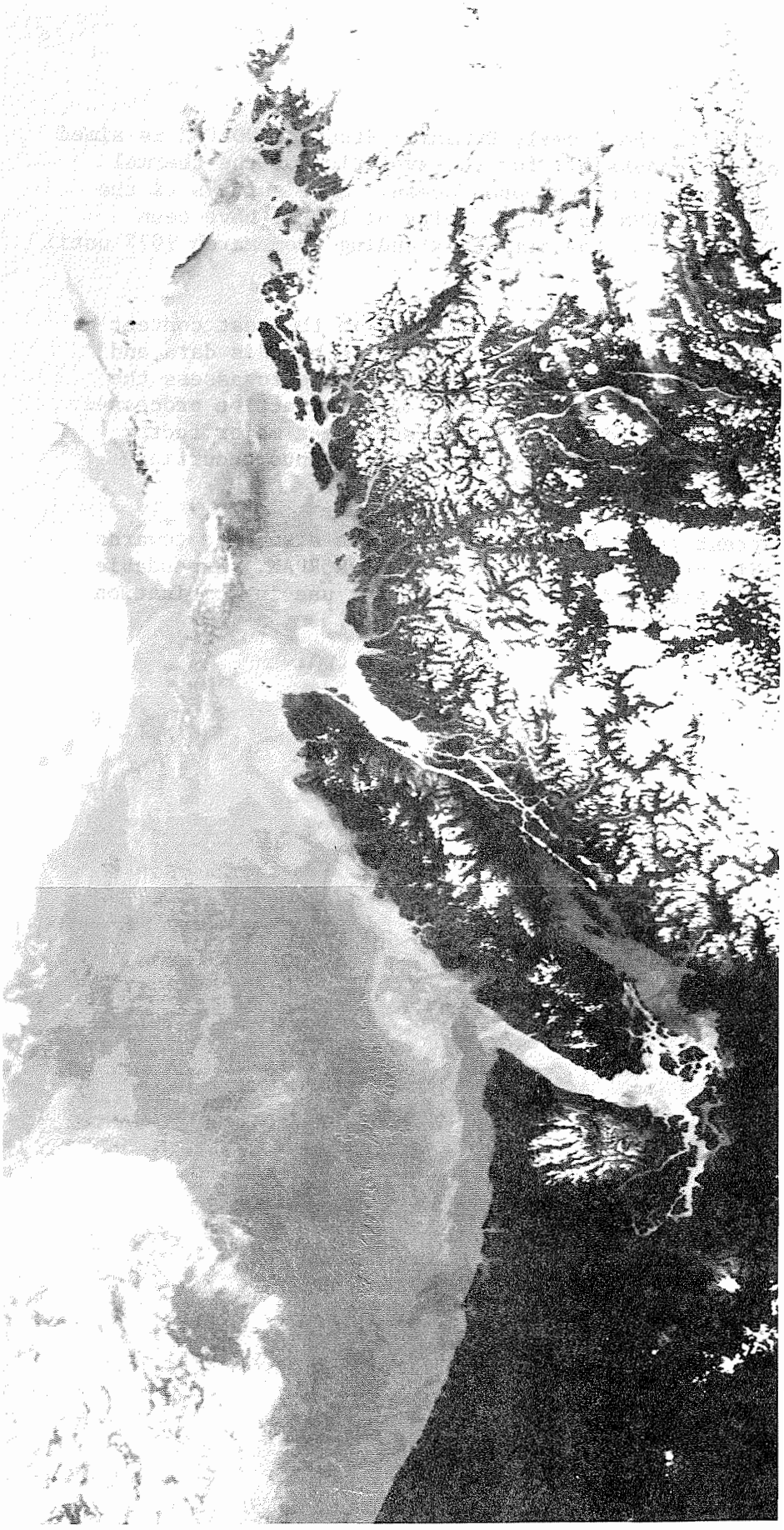
along Line P during 1979. The magnitudes of the observed temperatures are compared to the corresponding long-term averages (based on data taken usually over 20 years) by passing them through a step filter whose jumps are chosen from multiples of one half standard deviation ($\frac{\sigma}{2}$). "0" represents temperatures within $\pm\frac{\sigma}{2}$ of the long-term mean; "+1" indicates positive anomaly with value falling between $\frac{\sigma}{2}$ and σ; similarly "2" represents positive anomaly with value falling between σ and $\frac{3\sigma}{2}$, etc.

Quality of Sea-surface Temperature Data

Knowledge of reliable sea-surface temperatures of the ocean is becoming increasingly important for understanding the influence of ocean temperatures upon weather and climate patterns (where even an anomaly of a few degrees of ocean temperature can affect these patterns), and for calibrating satellite observations of sea temperatures. For this reason, during the past few years a series of studies has been undertaken to examine the quality of sea-surface temperatures and salinities obtained in the northeast Pacific Ocean, from a number of platforms, including weatherships, research ships, anchored U.S. environmental buoys and merchant-naval ships, and employing a variety of instruments - ordinary bucket thermometers, specially-designed bucket thermometers, reversing thermometers, engine-intake temperature recorders, expendable bathythermographs (XBT), salinity-temperature-depth recorder (STD) and thermosalinographs. The results of most of these studies have already been reported. During the past year the remaining study was concerned with the difference between the accuracy of temperature measurements made by a specially-designed bucket thermometer and the engine-intake thermometer aboard the two weatherships CCGS *Quadra* and *Vancouver*. This study was required to clarify a controversy surrounding the relative merits of the two main methods of sea-surface temperature observations used routinely by merchant-naval ships. The results indicated that the mean difference between the bucket and engine-intake temperatures and the associated standard deviation for data from *Quadra* were both small, (a mean difference smaller than $0.1^{o}C$ and a standard deviation also less than $\pm 0.1^{o}C$) and consistent during the first five cruises over the one year period. For subsequent cruises both the mean difference and standard deviation varied considerably. It was concluded that the engine-intake thermometer requires calibration at least once a year in order to maintain the quality of the data. The mean difference and the associated standard deviation for data from the *Vancouver*, on the other hand, both fluctuated appreciably from one cruise to another. This is attributed to a faulty measuring system aboard this ship. The study further indicated that the engine-intake method can indeed provide reliable sea-surface temperatures that are as accurate as those obtained by the use of specially-designed thermometers, provided that an upper mixed layer exists when measurements are made.

Satellite Derived Surface Sea-temperature off B.C. Coast

Infrared satellite imagery of the waters off the Pacific coast of Canada for the five-year period (July 1974 through July 1979) have been examined in order to delineate sea-surface temperature patterns in the area. A series of charts depicting oceanic thermal fronts has been compiled. The source data consists of enhanced infrared imagery in photographic-print format, obtained mostly from the National Satellite Services Branch of National Climatic Center (NOAA), some from its San Francisco Field Station and also some from the Arctic Weather Centre of the Atmospheric Environment Service of Canada. With regularly obtained imagery in print format, only two shades of the grey-tone variations of the sea surface can be delineated successfully by an optical device. However, with suitably-enhanced imagery made from original data that is processed locally, at least six shades of these variations can be differentiated. The imagery has been found useful to explain the occurrence of certain water types and has provided better insight into the detailed circulation off our coast.



The figure illustrates an example of very high resolution radiometer (VHRR) NOAA-5 infrared imagery of Western Canada and the USA, including the waters off the Pacific coast, based upon data taken during the daytime overpass at 22:34 GMT, 14 July 1979. Light and dark tones represent lower and higher temperatures, respectively. The coldest oceanic waters occur in Juan de Fuca Strait and Queen Charlotte Strait, while the warmest waters are found off the coast of Washington and Oregon. The well-defined tongue of cold water lying offshore of Juan de Fuca Strait, with source water along the west coast of central Vancouver Island, may be associated with the southward flow of coastal water.

Ocean Response Study

IOS participation in the Anomaly Dynamics Study of NORPAX is aimed at resolving the mechanisms responsible for the evolution of the thermal structure of the upper 300 metres of the open ocean. AXBT surveys of the North Pacific between 50°N to 40°N in the vicinity of 170°W, have been conducted on a bi-weekly basis for the period extending from March 1977 until April 1979.

Seasonal changes and interannual variation in the heat content were assessed at various latitudes. From a combination of this data and information about the horizontal gradients, it is possible to assess the importance of one dimensional processes in relation to advective processes. From this study it is clear that advective processes are a major factor in creating both the interannual variations and other events occurring below the mixed layer to the 150 metre level.

During the current year, further progress was also made towards participation in the "ship-of-opportunity program" of NORPAX. Expendable CTD systems have been evaluated and they are ready for use in combination with surface salinity and temperature sensors.

NUMERICAL MODELLING SECTION

R. F. Henry - Head

P.B. Crean
M.G.G. Foreman (Computing Services)
T.S. Murty
P.J. Richards

The Numerical Modelling Section continues involvement in the development and application of numerical modelling methods for simulation of oceanographic problems, in cooperation with other groups.

A time-dependent two-layer hydrostatic numerical model, to simulate internal surges or internal hydraulic jumps, was completed and applied successfully to Babine Lake and to a laboratory tank. Then, a more sophisticated model under the triple-deck approximation was developed which allowed partially for non-hydrostatic pressure effects and continuous density stratification. The most important feature of the triple deck model is that it permits separation of the flow on the downstream side of the sill. This model was successfully tested both for the natural scale as well as for the laboratory scale.

Preliminary work using analytical models was completed on the problem of nonlinear interaction between storm surges and astronomical tides.

Collaboration with NOAA and the University of Hawaii continued on two major tsunami projects. The first involved the development of a new objective scale for tsunami magnitude; the second involved numerical simulation of lateral waves with the goal of identifying them in tsunami records.

The manuscript of a comprehensive book on storm surges was completed.

Studies were begun of tidally-generated residual circulation. A linear model was developed and tested for the St. Lawrence estuary and work is in progress on nonlinear models of the same area and of Bridport Inlet on Melville Island.

Transmission of internal Kelvin waves in fjords was studied using a variety of methods. This led to a significant revision of a popular finite difference method for the shallow water equations. A barotropic ocean circulation model with negative eddy viscosity was completed.

A program for tidal constituent analysis based on high and low water observations was developed in order to process observations collected in the Arctic by the oil industry. The program permits analysis of records with missing data and inference of constituents.

Programs developed during the last two years for tidal height and current analyses were supplied to a number of researchers in Canada and abroad. The relevant manuals were revised and reprinted. Mike Foreman was invited to the University of Hawaii to install the tidal analysis package and advise on its use.

Numerical model studies of the Georgia/Fuca system in 1979 have primarily been concerned with exploratory stratified flow simulations and analyses of earlier barotropic tidal model output.

The object of the numerical experiments on stratified flow is to find a viable means of simulating the estuarine circulation in a topographically complex deep coastal sea subject to strong tidal mixing when the time scales of important changes on the open boundaries require extended model runs. Using a laterally integrated two-dimensional numerical scheme (x, z, t, dependent), mixed tidal co-oscillations have been simulated for the homogenous fluid case in a gulf of variable width and depth approximating the main channels. Encouraging initial results have been obtained in which internal seiche motions and associated mixing in a stratified rectangular basin, of dimensions approximating those of the Georgia/Fuca system, have been simulated using both free surface and the less expensive "rigid lid" approximation.

Analyses of the output of the coarse grid and fine grid barotropic tidal models have been undertaken by a private firm of consultants. These include harmonic analyses and predictions of the tides and currents, together with energy volume flux and residual flow calculations. The residual barotropic tidal circulation obtained from a one month run of the fine grid model clearly shows the effects of the major topographically induced eddies in the tidal streams.

It appears probable that a proposal to continue work on the upper layer buoyant spreading model of the Fraser River plume, by the same firm, will be funded. An extensive field program is included, which would involve cooperation of the Canadian Coast Guard.

Field operations during the year included further drogue tracking exercises, which verified the existence of the large tidal eddies that give rise to marked residual circulation, and observations on the shallow banks near the mouth of the Fraser River. Together with earlier observations, the latter have provided a plausible qualitative dynamical explanation of the effects of the tidal changes in elevation in the adjacent strait on the discharge pattern at the river mouth.

REMOTE SENSING SECTION

J.F.R. Gower - Head

J.S. Wallace

The Remote Sensing Section has responsibility for development of aircraft and satellite remote sensing techniques for oceanography, and for evaluation of techniques originating elsewhere.

Even though its useful life was limited to four months during the summer of 1978, the oceanographic satellite, SEASAT A, provided enough data to keep the scientists who were involved with the program, occupied throughout 1979. J.F.R. Gower is a principal investigator in three experiments studying synthetic aperture radar (SAR) imaging of roughness patterns due to internal waves, ocean waves and ocean current systems respectively.

The first experiment was organized jointly with B. Hughes of the Defence Research Establishment Pacific and involved very precise measurements of sea surface roughness properties during a SEASAT overpass. A laser surface slope meter was deployed by the CNAV *Endeavour* over internal wave patterns in Georgia Strait, north of Boundary Pass. The resulting surface roughness patterns were also imaged by the SAR on the Canadian Sursat aircraft. The aircraft and satellite data arrived slowly during 1979 and is being analysed to show how SAR's respond to surface roughness viewed at different angles and with different wavelengths, polarizations and resolution.

The second experiment represents the major U.S. NASA/NOAA check on accuracy of the SEASAT SAR for measuring ocean waves. Canadian participation consisted of providing data from ocean Station PAPA, from the Tofino wave-rider station and arranging flights with the SAR over the experiment sites to give more radar data than would result from SEASAT alone.

The third experiment is being conducted with P. LaViolette of the U.S. Navy NORDA in Mississippi and is designed to study imaging surface roughness changes induced by the thermal or dynamic effects of the Gulf Stream near the tail of the Grank Banks. The second field phase of the experiment met with limited success in June 1979 when bad weather held the ship back from the experiment area. Flights out of St. John's resulted in excellent thermal maps with current measurements and airborne laser surface roughness data. Although this phase took place after SEASAT's breakdown it showed the strong boundary layer modulation induced by the current, and will allow interpretation of the other aircraft and satellite radar data taken during the experiment.

Results from all three experiments have appeared in publications and reports, but as more sophisticated processing of the SEASAT SAR data continues, further conclusions can be made. In fact as the processing techniques for this type of radar become better understood and more widely available, it appears that high resolution mapping radar may one day be a standard sensor in space.

The joint Canada France Ocean Optics Experiment (CFOX) resulted in major field work during 1979. The purpose of this experiment was to bring together our airborne spectroscopic measurements of water colour with similar work and underwater optical measurements being made by A. Morel's group of the University of Paris. Joint operations were carried out (a) in the Ligurean Sea south of Monte Carlo (PROLIFIC) in March with a French DC-3 and French and Italian ships, (b) in B.C. coastal waters using the CFAV *Endeavour* and CSS *Vector* with a locally chartered aircraft in July and (c) in the Eastern Canadian Arctic in August using the chartered vessel *Theron* and chartered aircraft flying out of Pond Inlet and Resolute Bay. PetroCanada Ltd. and the Polar Continental Shelf Project supported this Arctic operation.

This has led to several improvements in processing of the airborne spectroscopic data which in turn allows generation of improved maps of chlorophyll concentration in Lancaster Sound and Western Baffin Bay. Data from NASA's Coastal Zone Colour Scanner flown on Nimbus 7 was collected for all of the above areas but has not yet come available through their overloaded data processing system.

Other chlorophyll mapping flights were made along the B.C. Coast by Seakem Oceanography Ltd. as part of an experimental survey with a ship of opportunity. Data from these flights has also added to our understanding of chlorophyll distribution and the problems of mapping it from the air.

OCEAN CHEMISTRY DIVISION

C.S. Wong - Head of Division

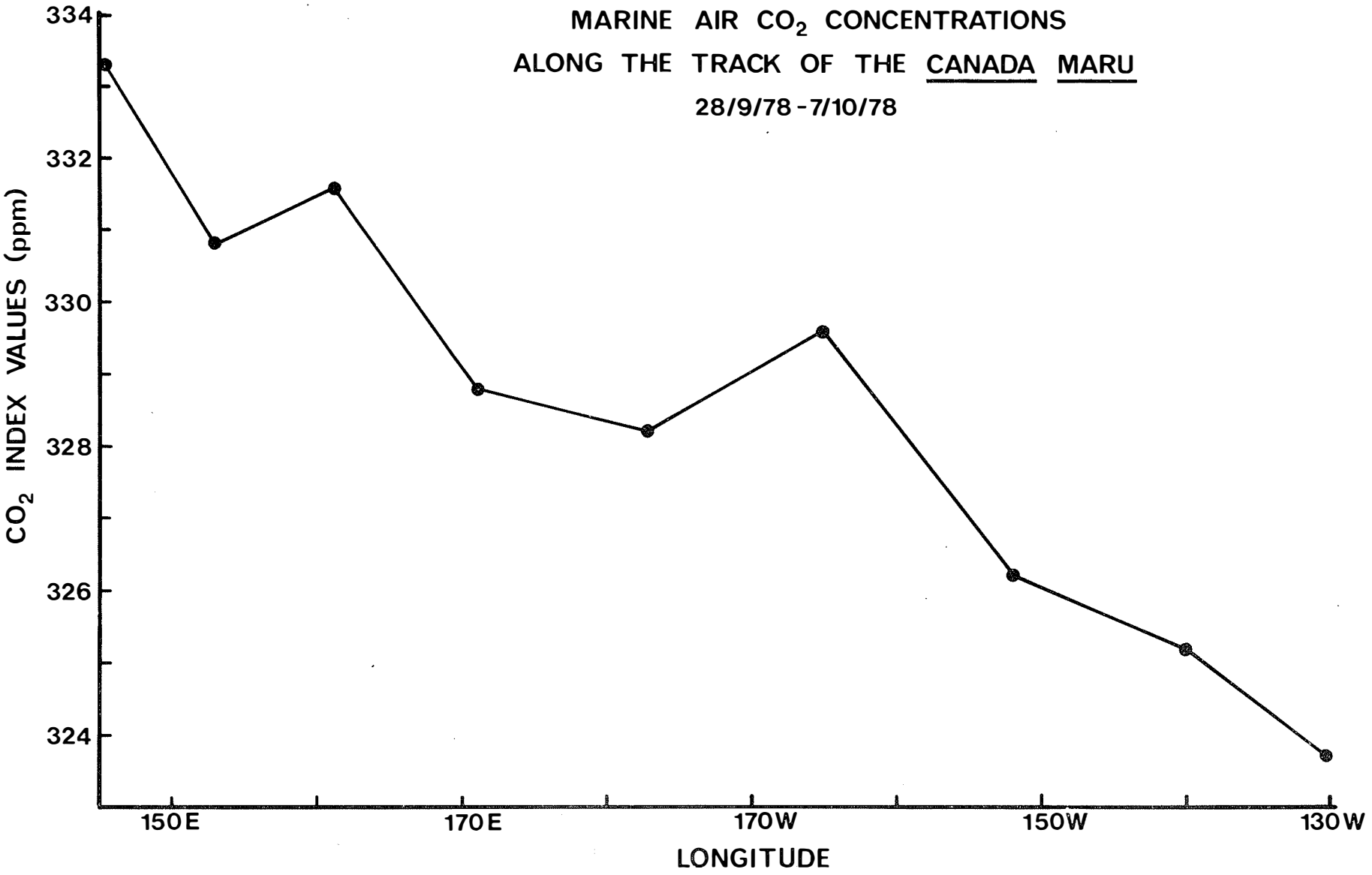
R.D. Bellegay
W.J. Cretney
*K. Iseki
W.K. Johnson
D.M. Macdonald
R.W. Macdonald
F.A. McLaughlin
P.S. Munro
J.S. Page (Computing Services)
D.W. Paton
T.J. Soutar
*V. Stukas
J.A.J. Thompson
F.A. Whitney

*Left in 1979

The primary responsibility of the Ocean Chemistry Division is to provide expertise and advice in the chemical aspects of the marine environment in B.C. coastal waters, the western Arctic and N.E. Pacific Ocean; to conduct the necessary research and monitoring activities at the regional, national and/or international level in order to contribute to policy, legislation and scientific knowledge and in particular to provide an understanding of the chemical effects of human activities on the ocean, its suspended matter and bottom sediments, and the effect of the ocean on man's activities. These effects must be distinguished from natural and often non-systematic variations thereby requiring long-term and sustained research effort. A secondary role is to understand the interaction of the inorganic and organic material with the marine biota and geological reservoirs in order to provide chemical oceanographic information including chemical uptake-release processes that are useful in fisheries research, in geological studies and in investigations of water transport and mixing.

Through active support of the Federal Government Make-or-Buy policy, the Division has achieved the goal of establishing a viable and credible capability in private industry on the west coast. Industry is now able to conduct chemical oceanographic studies related to ocean dumping, environmental contaminants, oil pollution and environmental impact assessment of mine tailings disposal, arctic drilling and industrial activities. These short-term, site-specific studies which are frequently of immediate concern to the public, will continue to be pursued mainly via the contract route under the supervision of the Division.

The in-house effort is directed towards pursuit of the longer-term but equally important research problems. These include the influence of oceanic carbon dioxide (CO_2) on climate and chemical variability in the ocean. Often, unique and expensive facilities are required, for example, ultra-clean laboratories for analysing trace metals and hydrocarbons, a heavy-isotope mass spectrometer for accurate trace metal measurements, a gas chromatograph/mass spectrometer/data system for identification of oil and chlorinated compounds and an infrared CO_2 calibration and analytical laboratory for CO_2 geophysical


MARINE AIR CO_2 CONCENTRATIONS
ALONG THE TRACK OF THE CANADA MARU
28/9/78 - 7/10/78
CO_2 INDEX VALUES (ppm)
334
332
330
328
326
324
150E
170E
170W
150W
130W
LONGITUDE

time-series studies. These facilities enable us to maintain a state-of-the-art capability in ocean chemistry, with sufficient scientific capability to supervise contracts, scrutinize work performed by the private sector and to provide the necessary scientific expertise to advise policy-makers in an effective way.

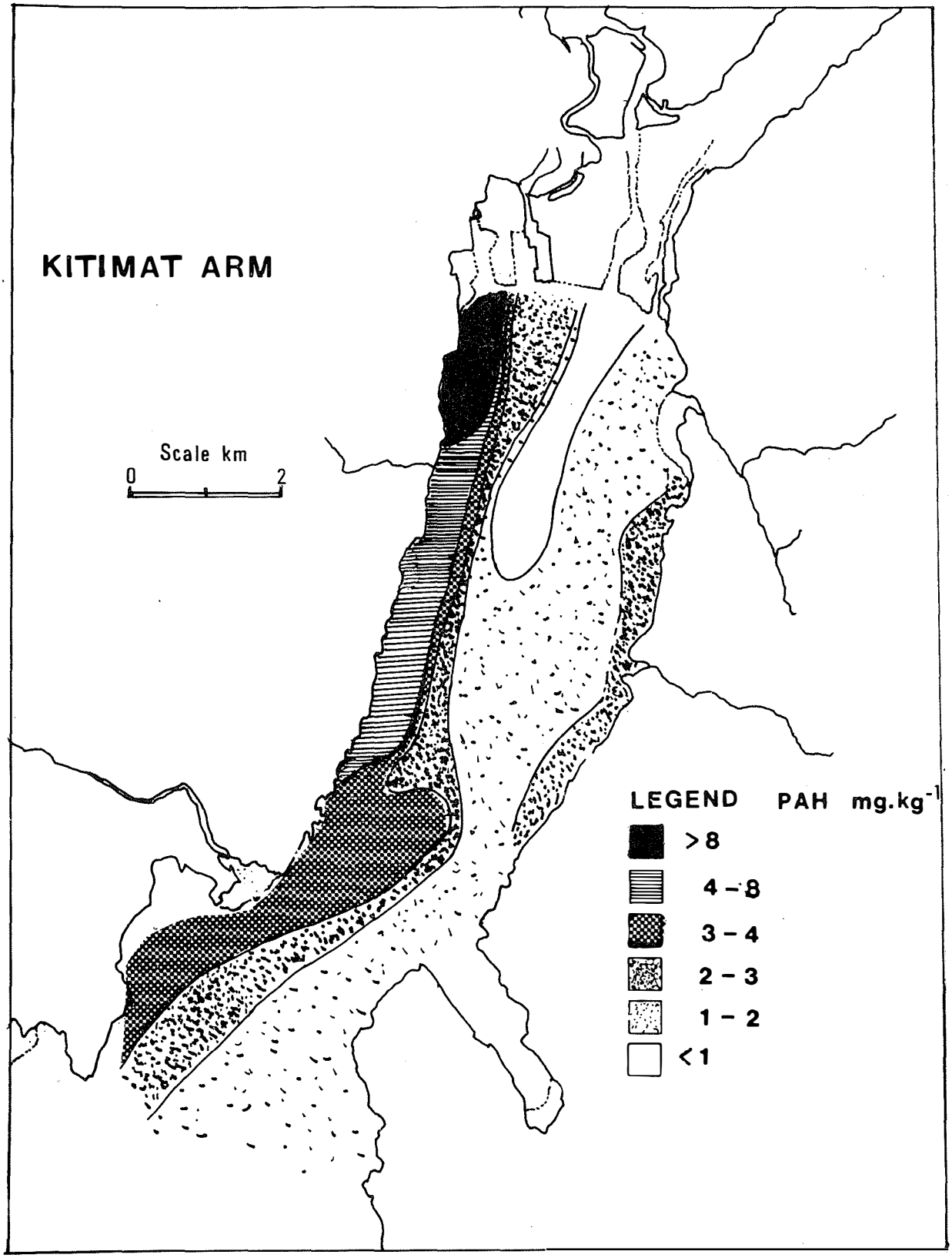
Marine Carbon Research Centre

CO_2 has emerged as a leading environmental problem that will remain with us well into the future. The ocean is expected to play the most important role as the major sink for CO_2 released into the atmosphere through fossil-fuel burning. Over a few hundred years it is expected to absorb five to eight times the present atmospheric level of CO_2. There is a great uncertainty in knowledge of marine CO_2 variability and pathways. To tackle this difficult and long-term problem, a marine carbon research centre was created to focus our national and international marine CO_2 activities, to collect multi-disciplinary information for synthesizing a coherent picture of the complex marine carbon cycle, to provide a uniform, long-term analysis and inter-comparison of Canadian CO_2 data and to disseminate CO_2 data through publication of geophysical and geochemical monitoring time series. This centre complements the AES Climate Centre where a major effort is directed towards modelling the climatic effects of fossil fuel derived CO_2.

The CO_2 problem is international. All of us contribute to the atmospheric CO_2 increase by burning oil and coal to keep our houses warm and to keep our civilization moving. The research problem is so immense that it must be solved collectively by generations of teams of scientific workers - each team contributing knowledge to only a few aspects of what is a global problem. Our contribution has been directed towards collecting and interpreting time-series measurements of CO_2 over the ocean. This year marks the tenth anniversary of the CO_2 time-series at Ocean Weather Station P (50^oN, 145^oW). However any celebration was overshadowed by the possibility of termination of the weatherships in the near future. Two replacement programs are under way: one involves weekly collection of atmospheric CO_2 samples at lighthouses at Amphitrite Point, Kains Island and Cape St. James, on the west coast of Vancouver Island and Queen Charlotte Islands, and the other involves "ship of opportunity" collection of air and oceanic samples by the *Canada Maru* en route across the Pacific Ocean. Preliminary results from Pacific Ocean transects indicated very large spatial variations in marine air CO_2 concentrations as well as seasonal fluctuations. A long time-series would be required for effective data interpretation.

In addition to Station P analysis, our infrared laboratory has been performing air CO_2 analysis for other Canadian CO_2 stations at Sable Island in the Atlantic and at Alert in the Canadian Arctic, both manned by the Atmospheric Environment Service.

Observations of atmospheric and oceanic CO_2 were made during the First GARP Global Experiment (FGGE) cruise of the *Parizeau*, December 28, 1978 to March 3, 1979 between Victoria and 2^oS, 150^oW. Air and sea water samples for CO_2, ^{13}C and radiocarbon, nutrients and carbonate chemistry were collected. Continuous CO_2 partial pressure measurements indicated a super-saturation of



Concentrations of PAH (Polycyclic aromatic hydrocarbons) in the surface sediment in Kitimat Arm, an environmentally sensitive area along the northwest British Columbia coast.

CO_2 up to 80 x 10^{-6} parts per million of volume in the equatorial waters with respect to atmospheric levels, according to the preliminary data. Checks will be made on the calibration and previous work by Scripps Institution of Oceanography in the area to see if an increase in pCO_2 in seawater is observable.

The last of a long series of CEPEX controlled experiments was performed in Saanich Inlet from June 2 to July 5, 1979. The study concentrated on heterotrophic transfer of carbon in the utilization of glucose enrichment in controlled systems, an idea initiated by Professor T.R. Parsons of the Department of Oceanography, University of British Columbia (UBC). The work was carried out as a co-operative project with UBC, Simon Fraser University and Southampton University in the U.K. Carbon fourteen-labelled D-glucose was added to plastic enclosures containing 65,000 liters of seawater to produce glucose enrichments of 1 mg/L and 5 mg/L. Observations of nutrients, pH, O_2, chlorophyll *a*, primary production, carbonate chemistry, particulate organic carbon, dissolved organic carbon, phytoplankton, zooplankton, bacteria and other environmental parameters such as light intensity, particle-size distribution, temperature and salinity were made. Excess glucose tended to suppress photosynthetic activities in the enclosures which also exhibited high removal of dissolved oxygen. There was a large increase in bacterial biomass in the 5 mg/L bag. From the ^{14}C-labelled experiment, it was determined that approximately 13% of the particulate carbon remained while 87% of the glucose was remineralized to CO_2.

Marine Hydrocarbons - Kitimat Baseline

The general objective of this program is to understand the occurrence, pathways and fate of hydrocarbons (natural, petroleum, PCBs and pesticides) in the marine environment. The main emphasis in 1979 was placed on an environmental baseline study at the Kitimat Harbour and its approaches.

Kitimat, which has been proposed as a possible oil port site to receive Alaskan crude for trans-shipment, is located at the head of an environmentally sensitive fjord system. Future industrial growth is also expected to be high in this northwestern B.C. coastal region. A baseline study, submitted as an unsolicited proposal by Seakem Oceanography Ltd., was performed under Ocean Chemistry Division supervision. A series of cruises on chartered vessels was conducted. Those in 1979 included a February 5-16 cruise to collect samples of sea water, marine organisms and sediments for baseline hydrocarbons and nutrient study, together with background chemical oceanographic data, an April 8-13 cruise mainly to collect mussels and clam samples for histopathological analysis, and a July 22-26 charter cruise to Port Alberni to collect samples for estimation of polyaromatic hydrocarbon levels in sediments and inter-tidal mussels.

It is not easy to establish the baseline conditions in the Kitimat area. The marine environment is continually being subjected to input from aluminum plant and pulp mill effluents. It is equally difficult to interpret the relationship between levels of polyaromatic hydrocarbons (PAH) measured with the physiological disorders observed in marine bivalve mollusks collected in the area. Thus, collection of similar organisms was made in an area already known to be polluted by pulp mill effluents near Port Alberni.

Preliminary results showed a highly variable level of polyaromatic hydrocarbons in the tissues of mussels from the western side of Kitimat harbour. However, a statistical correlation was found between the sediment levels of PAH and the incidence of a particular proliferative cellular disorder in mussels and clams from the Kitimat area.

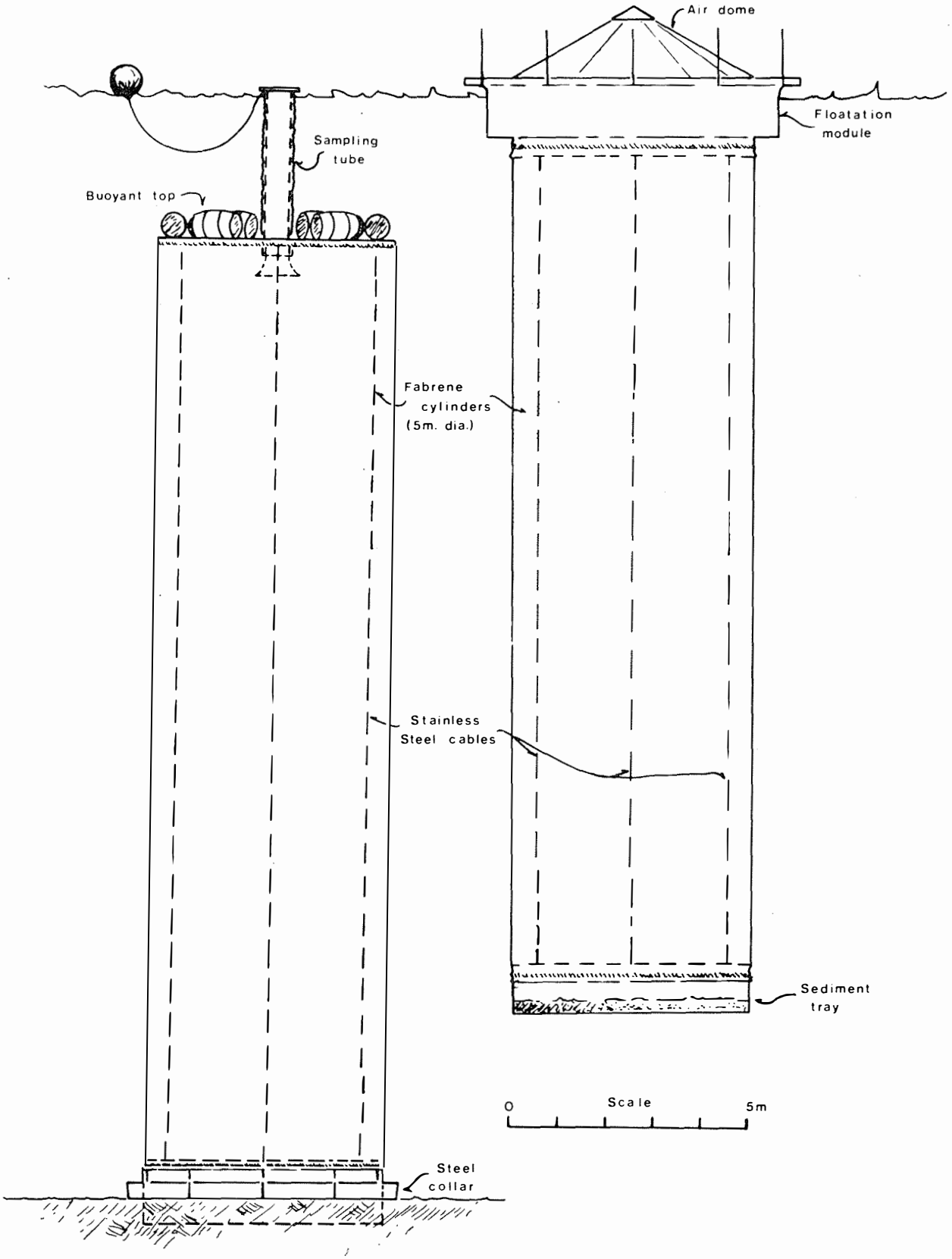
As in the case of trace metals, a unique clean room has been established for hydrocarbons. The major facility, a gas chromatograph/mass spectrometer system was upgraded with the acquisition of a Finnigan INCOS MS data system. This enables the group to perform multiple ion detection, display the spectra and compare the data to an extensive library of compounds as well as interfacing to other INCOS/systems in the nation. A library of compounds is being established to serve as an identification centre for petroleum and other hydrocarbons in the marine environment of the western coast.

Supported by Ocean Dumping funds, a study was made of the variability of PCB contaminants in dredged spoils to examine the reliability of sampling and analysis techniques for use under the Ocean Dumping Act. Replicate sampling of mud was carried out in Victoria Harbour prior to dredging, and in several barges loaded with dredge spoil destined for ocean disposal. Analysis of variance was applied in order to determine where significant variations were occurring, and how best to sample to obtain reliable but inexpensive information. For example, adequate sampling prior to dredging in a new area could reduce monitoring required later at the dumpsite.

Chemical Controlled Experiments

CEPEX (Controlled Ecosystem Pollution Enclosure Experiments), with the original objective to study pollution stresses on natural plankton populations was terminated in 1979 by National Science Foundation in the U.S.A. The facilities installed in Saanich Inlet near the site of the Institute of Ocean Sciences, including large and small floats and bag systems, were officially transferred to the Ocean Chemistry Division for future chemical studies, and for herring experiments by fisheries scientists.

A new system, CHEMCELL, which includes the additional dimension of the sediment/water interface is being developed and constructed via an unsolicited proposal by C.E.L.L. at Victoria under the scientific authority of Ocean Chemistry Division. The new system consists of a flexible plastic bag attached by a steel collar to the bottom in Saanich Inlet at one end and a dome system to enclose an atmosphere at the other end. An international SEAFLUXES program to study the air-sea boundary fluxes and the seawater/sediment boundary interaction is being consolidated. Tentatively, it will involve Ocean Chemistry Division, the Department of Oceanography at UBC, and the Institut für Meereskunde at Kiel, F.R. Germany, the Institute of Biological Sciences & Environmental Sciences at the University of Tsukuba in Japan, individual scientists from U.S.A. and France as well as the Quebec Region of Fisheries and Oceans.



Designs of the CHEMCELL Experimental Systems for chemical controlled experiments under the SEAFLUXES program to be conducted in Saanich Inlet near the Institute of Ocean Sciences.

Coastal Pollution

Mining is one of the major industries in B.C. Its tailings disposal is of great concern to the environment departments of the provincial and federal governments. Pollution from sewage outfalls is of major concern to the public and municipalities. These studies form the main thrust of the coastal pollution program.

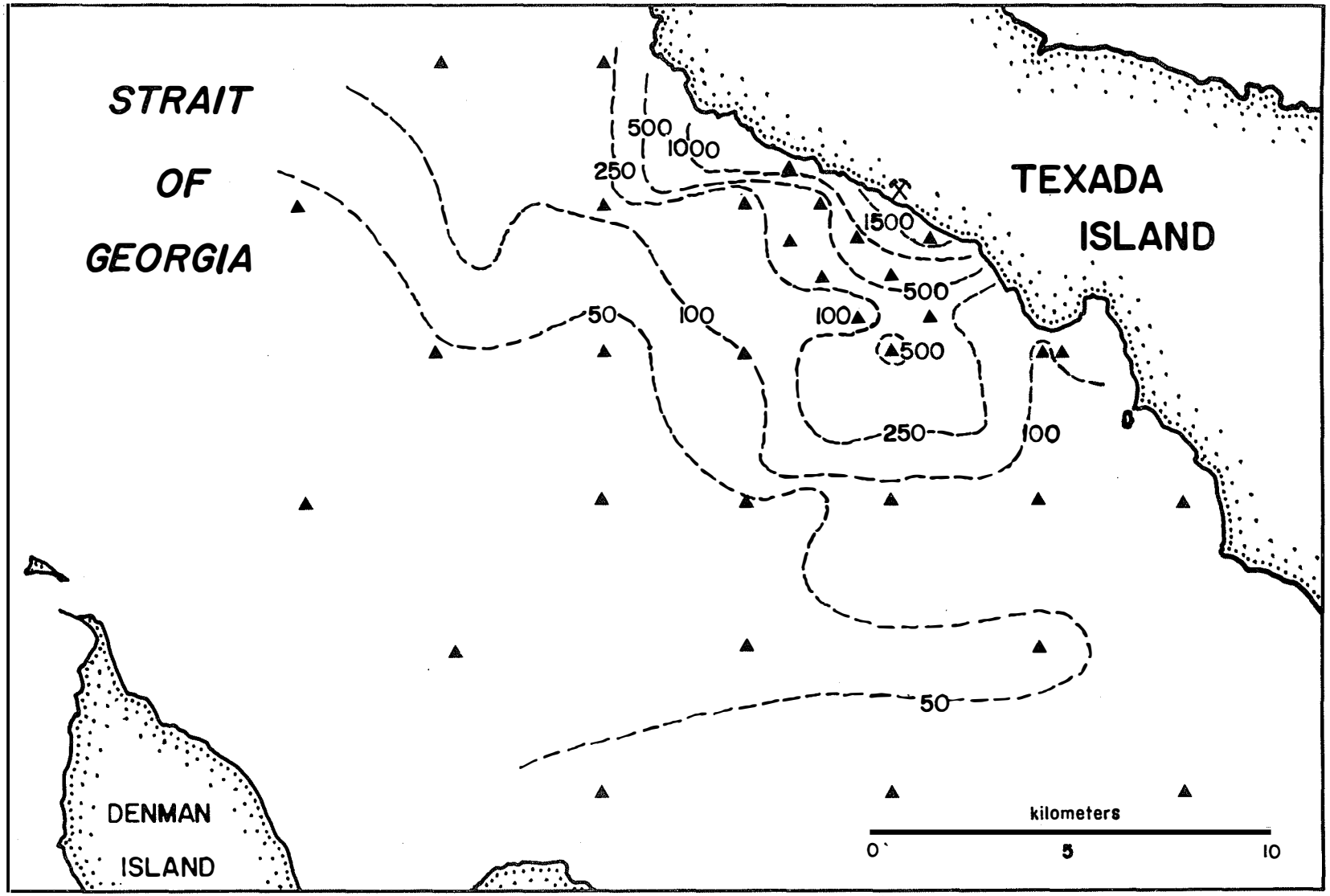
Emphasis has been placed on understanding the levels and trends of heavy metals in marine organisms in polluted areas, determining the mechanisms of transformation of these metals into toxic forms, as well as detoxification mechanisms operating within marine organisms. The heavy metals copper, zinc and cadmium in the holothurian *Molpadia intermedia* were studied to determine the suitability of using this as a possible monitoring organism for the Point Grey Dumpsite. No significant differences were observed when compared to those from a control area. A similar study is underway for marine organisms collected near the Macaulay outfall area in Victoria.

Methylation of heavy metals in the marine environment is not well understood. For example, mercury can be methylated by marine organisms and bacteria into the more toxic methylmercury forms of CH_3Hg^+ and $(CH_3)_2Hg$. To understand similar processes for several other metals introduced by dumping of mine tailings into the marine environment, contract research was conducted on lead and arsenic. Funded by Ocean Dumping funds, a contract was awarded to Beak Consultants Ltd. for study of the methylation of lead in sediment samples from Burrard Inlet, Goletas Channel, Granby Bay where there is an abandoned copper mine and Alice Arm where inactive molybdenum mines have historically disposed of high-lead content tailings. Results indicated that discharge of lead-bearing particulates did not appear subject to mobilization of lead by methylation under anoxic conditions. A study of the methylation of arsenic in marine sediments and interstitial waters in Rupert Inlet, B.C. was pursued under contract to Beak Consultants Ltd. using sediment samples from areas polluted by copper mine tailings. Results suggested that arsenic did not appear to pose a significant hazard. No arsenic species were detected in sea water while in the interstitial waters, total inorganic arsenic varied between 3.5-4.9 µg/L possibly correlated with tailings loading. Incubation of sediments with nutrients indicated that the degree of arsenic methylation depended primarily upon arsenic availability.

Organotins were designated as a class of contaminants of high priority in the Environmental Contaminants list. Under Environmental Contaminants Act funding a contract is underway with Dr. Cullen of UBC to develop analytical procedures for organotins in order to investigate the occurrence, and nature of tin compounds in sewage and industrial effluents in both fresh and marine waters.

Trace Metals

The main objective of the program is to assess the natural and anthropogenic inputs of physiologically significant trace metals into the marine environment and their interaction with suspended matter, the planktonic biota and surface sediments.



Isopleths indicating copper concentrations in marine sediments in µg g-1 (dry weight) in the vicinity of Texada Mine near the central part of Georgia Strait, B.C.

The trace metals work is directed towards several major long-term efforts. The first is to assess the gap in knowledge between marine chemists engaged in attaining meaningful levels of trace metals in seawater and those working on modelling of chemical speciation and biological effects of trace metals. A NATO-funded organizing committee with this direction was held at Ocean Chemistry Division, which received a NATO grant to organize an Advanced Research Institute in Europe in 1980/81 to summarize the state-of-the-art on accurate measurements of trace metals in sea water and research directions. The second objective is the continuation of long-term work on accurate measurements of trace metals by using ultra-clean laboratory techniques coupled with mass spectrometer and other instrumentation, with the plan to develop a "standard sea water" with concentrations near to natural levels in open ocean. This year's work involved confirmation of the state of cleanliness of the ultra-clean laboratory, measurements showing a hundredfold reduction of metals being atmospherically transported in a normal laboratory. A long-term storage test on lead, mercury, cadmium, zinc, copper, nickel, cobalt and iron in seawater is underway. The third objective is to understand and model the flux of metals between and accumulation of metals within the important environmental compartments; sea water, marine biota and surface sediment. This problem is being addressed through a five-year SEAFLUXES program (Sediment/ecosystem/atmosphere flux enclosure study). The present phase is the construction of the experimental system being carried out through a $270,000 unsolicited proposal, previously described under Controlled Experiment.

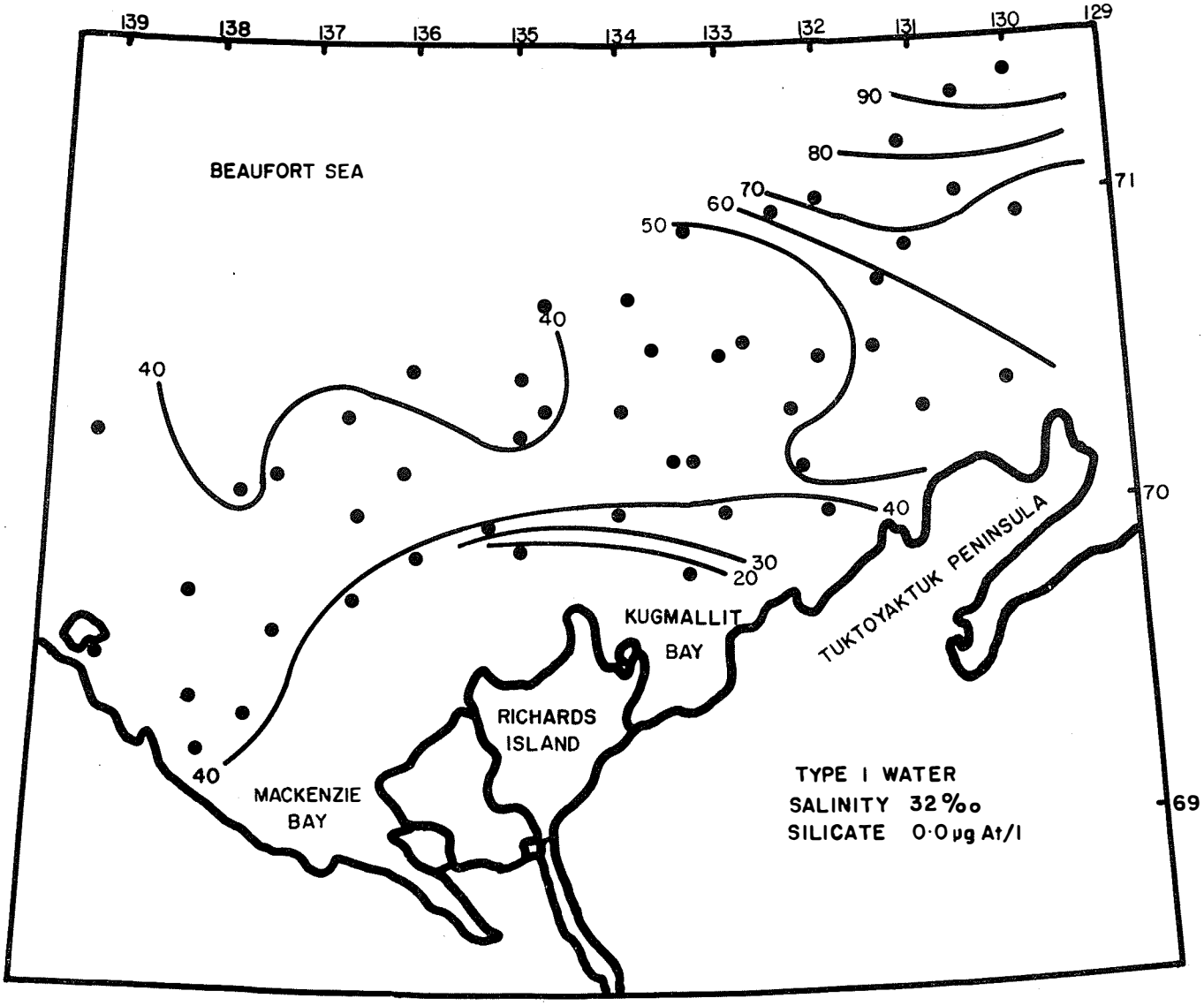
For ocean dumping work, research through contract is being carried out on a selective extraction scheme for trace metals for marine sediment and dumped material so as to improve the effectiveness of regulations. Two cores were collected; one each from Victoria Harbour and False Creek and subsamples were subjected to the ultriate test as well as an extraction scheme to separate metals into the different chemical fractions of (1) interstitial water, (2) exchangeable, (3) easily reducible, (4) oxidizable, (5) moderately reducible and (6) residual. Results showed that the largest metal reservoirs were in general the oxidizable and the residual compartments but mercury, an exception, was located in the residual phase mainly. Results of the release experiments carried out at low particulate levels in seawater showed that residual Hg was not mobile. There was evidence, however that about 50% of the Cd was mobilized.

The time-scale of natural sedimentation and metal loadings due to mining activity near a lake in the Kootenay area of B.C. was studied in cooperation with Dr. Pharo of Canada Centre for Inland Waters by providing lead-210 dating and interpretation at Ocean Chemistry Division. The effects of dumping mine tailings from a lead-zinc mine were assessed in relation to the natural sedimentary processes occurring. Against a background value of about 2-4 μg lead cm^{-2} yr^{-1}, the lead flux has increased by an order of magnitude or more since 1905 due to mining.

Arctic Waters Chemistry

No field work was attempted in 1979. The major effort was devoted to working up the backlog of data and samples. Lead-210 dating of marine sediment in cores collected in Amundsen Gulf was obtained by a beta-counting technique. Nutrients and chemical oceanographic data from the Beaufort Sea were processed into report format.

Salinity and dissolved (reactive) silicate were used to study the origin of surface water for the southern Beaufort Sea. By this method it was possible to estimate the relative contribution of sea-ice melt, Mackenzie River water and high salinity, but nutrient depleted, water off the Tuktoyaktuk Peninsula.



PERCENTILE TYPE I WATER

Contours of the percentile contribution of water with the composition of 32°/oo salinity, 0 µg. At. L^{-1} of dissolved silicate

Weathership Program

Open-ocean effort was devoted to a continuing study of the long-term trends of chemical parameters at Ocean Weather Station P (50°N 145°W). In 1979, part of the effort was diverted towards establishing a replacement program in anticipation of the phase-out of the weatherships in 1981. Neuston-net tows were made between Victoria and Station P to collect tarballs and other surface pollutants. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon were taken together with some continuous shipboard infrared measurements of marine air CO_2 and pCO_2 on the CCGS *Quadra*. Samples of nutrients were taken to provide information about long-term fluctuations and their relationship to circulation and the marine food chain. Particulate detrital organic carbon and chlorophyll *a* were also collected on the *Quadra*. Seasonal flux of particulate carbon down to intermediate waters of 1,000 m was observable in the summer, confirming an earlier study by the late Dr. John Strickland and Dr. Parsons, although the carbon flux appeared to be smaller by the present technique.

OCEAN ECOLOGY LABORATORY

R.O. Brinkhurst - Head of Division

M.J. Austin
K. Denman
*R.H. Herlinveaux
D. Mackas
S. Hill

*Joined during 1979

The major 1979 field effort of the Ocean Ecology section focussed upon an intensive study of the biological oceanography of the continental shelf region off southwest Vancouver Island. Our objectives in this program have been twofold. First, we are attempting to identify major features in the spatial and temporal patterns of plankton abundance (important because planktonic productivity forms the base of the food chain leading to pelagic and demersal fish stocks). Second, we hope to learn the links between the physical and biological systems and, in particular, to know which physical processes determine the location, timing, and intensity of plankton blooms in this region.

Sophisticated sampling technologies are essential to our plans for rapid and detailed survey of the continental shelf region. We have developed two unique automated systems in response to this need. One is a computer-interfaced vertical profiler which contains sensors measuring chlorophyll fluorescence, temperature, salinity, light transmittance, and depth. Continuous information from these sensors is used to select water bottle samples at up to ten discrete depths per sampling site. The water samples are subsequently analyzed for dissolved nutrients (essential for phytoplankton growth), dissolved oxygen (both a measure of previous biological activity and

a tracer of water movements), carbon fixation rate (a measure of present phytoplankton growth) and salinity (a check on the operation of the continuous sensors). The second data collection system is supplied with sample water from the ship's plumbing and measures phytoplankton and zooplankton concentrations while the ship is underway. Graphical display of the data is available immediately, and allows the construction of maps of near-surface plankton concentration over relatively large areas. An example of one of these maps appeared in the previous annual report. These maps are used to help select the optimum locations for detailed sampling of vertical distributions and processes by the profiler described above.

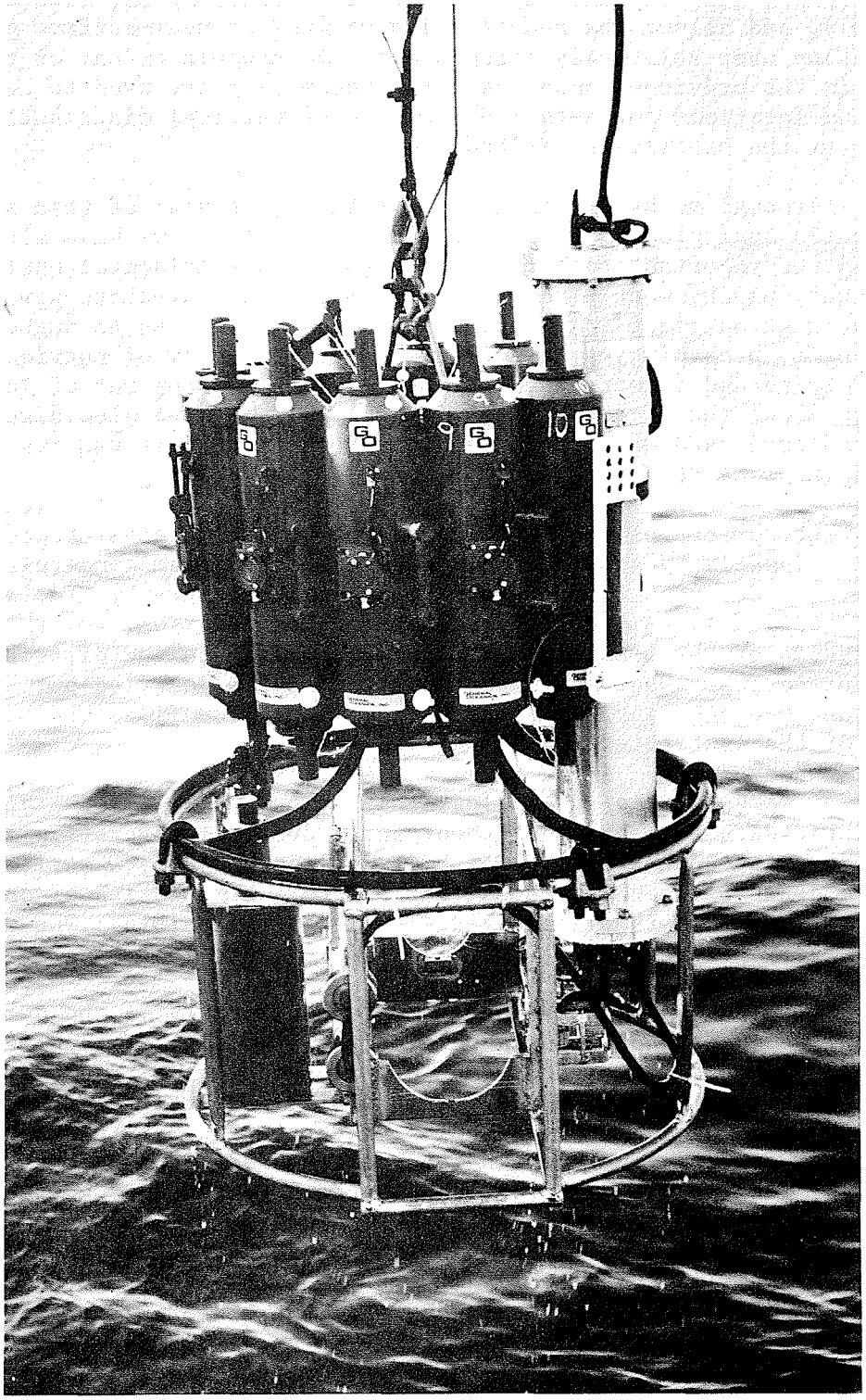
Although we have completed only the first year of this project and are currently analyzing data from the initial cruises, we have already identified two important features of the southern continental shelf ecosystem. We find that, unlike most places in the ocean, the near-shore portions of the shelf have high nutrient and phytoplankton concentrations throughout the summer months, probably resulting largely from the flow of nutrient-rich (due to tidal mixing and estuarine entrainment) surface water out of Juan de Fuca Strait and along the coast of Vancouver Island. We have also discovered a highly localized band of nutrient and plankton enrichment running along the outer margin of La Perouse Bank.

Interpretation and planning of the detailed research cruises was aided significantly by supplementary data collected from commercial ships of opportunity, under a contract issued to Seakem Oceanography Ltd. and administered scientifically by the Ecology section. In addition, for the detailed interpretation of our results, we will rely heavily on the distributions of surface currents as observed in the related programs carried out by the Coastal Zone Oceanography, Offshore Oceanography, and Tides and Currents Sections of the Institute.

At workshops in the spring, the various efforts to obtain bio-oceanographic data from ships of opportunity and from aircraft will be examined in relation to the weathership and lighthouse data series in an attempt to draw together a proposal for a future time-series of observations off the west coast of the island and elsewhere if feasible. The work will be done largely under contract.

Benthic studies have continued to concentrate on the demand for identification of marine oligochaetes and the provision of manuals for government and industry scientists on a world-wide basis. Surveys of estuaries in Europe and the U.S.A., and of oil-lease tracts of seabed have resulted in large benthic surveys being undertaken in many non-Canadian institutions, producing a large increase of knowledge and species to be described by the two active taxonomic centers here and in Sweden. The first international gathering of "sludge worm" biologists was held at the Institute with support by NESRC, University of Victoria and Fisheries and Oceans. The resulting volume will appear early in 1980. Three scientists from the USSR and one from Poland joined European and American authorities, and the second and third sessions are planned in Europe. Critical material was obtained as a result of a visit to Hamburg. Two major contract studies are in progress; one on the effect of worms on sediment cycling involving heavy metals and bacteria, one on the short and long term toxicity of various pollutants to resistant and sensitive species in the laboratory.

Ocean dumping permits were processed as usual, and the Ocean Dumping Research fund was administered, again with a workshop to analyse results and plan future work as well as to prepare a brief annual report.



Ocean Ecology vertical profiler

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

*N. St. C. Norton - Assistant Marine Superintendent (Deck)
R.W. Parkinson - Assistant Marine Superintendent (Eng.)
D.J. Redman - Design Draftsman
D.A. Doyle - Secretary

*Left in 1979

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1979 hydrographic and scientific programs and for various federal departments and universities.

CSS *Parizeau* (64.3 m overall, 1929 tonnes)

Master: A.G. Chamberlain Chief Engineer: P. Olcen

CSS *Parizeau* was employed in support of scientific and hydrographic programs involving Hydrography, Tides and Currents, Ocean Chemistry, Ocean Ecology, Offshore Oceanography; Loran C calibration; Pacific Geoscience Centre Geology; Department of National Defence, Ocean Acoustics; University of British Columbia, Oceanography.

CSS *Wm. J. Stewart* (65 m, 1920 tonnes)

CSS *Wm. J. Stewart* was sold to local interests and it is thought this ship will be used in a non-operational way in the tourist industry.

CSS *Vector* (39.6 m, 505 tonnes)

Master: K. Sjoholm Chief Engineer: R. Gibson

CSS *Vector* carried out programs in support of Coastal Zone Oceanography, Ocean Chemistry, Offshore Oceanography, Ocean Ecology; Pacific Environmental Institute, Biology; Environmental Protection Service; University of British Columbia, Oceanography; Simon Fraser University, Oceanography.

CSS *Richardson* (19.8 m, 78 tonnes)

Master: M.G. Wheeler Chief Engineer: I.N. Henderson

CSS *Richardson* was used mainly in Queen Charlotte Islands hydrographic survey and in search and rescue operations.

MV *Radium Express* (22.2 m, 100 tonnes) on charter

Master: I. Wiebe Chief Engineer: N. Boudreau

Mackenzie River and Mackenzie Bay hydrographic surveys continued with the MV *Radium Express*. 1979 marks the last year of this series of survey seasons on the Mackenzie River system.

MV *Pandora II* (58.2 m, 1220 tonnes) on charter

Master: R.A. Jones Chief Engineer: J. Newton

MV *Pandora II* carried out programs in support of Simon Fraser University; Environmental Protection Service; Ocean Chemistry and Offshore Oceanography; in conjunction with *Pisces IV*, the vessel supported programs for Coastal Zone Oceanography and Tides and Currents and supported *Pisces IV* during trials for the modified 2000 metre depth capability.

PISCES IV (6.1 m, 12 tonnes)

Chief Pilot: *I. Sanderson
F. Chambers

*Left in 1979

PISCES IV, our deep-dive submersible, received an extensive modification and was test-dived to 2000 metres. The development of a new tracking system is currently awaited which will enable this craft to perform at the maximum depth level of 2000 metres. *PISCES IV* was flown by Hercules to the Atlantic coast to undergo an interface exercise with the Canadian Forces vessel *Cormorant* and travelled to Lancaster Sound on the Canadian Forces vessel.

Barge *Pender*

Construction on the barge *Pender* was finally completed and the craft fitted out as a submersible tender vessel. The combination *Pender/Pisces IV* was towed to Jervis Inlet by the Canadian Forces Auxiliary Vessel *St. Anthony* on a successful shake-down cruise in December and work was performed for Pacific Geoscience Centre Geology on the return voyage to Patricia Bay.

Launches

CSS *Parizeau* hosted a four launch survey party in the Laredo Sound area and launches were used in Tuktoyaktuk and Summers Harbour in the Western Arctic.

Depot

The depot workshops continue to provide support to Institute activities in addition to the provision of repairs to ships and launches.

MANAGEMENT SERVICES DIVISION

N.A. Todd - Chief Management Services

Batchelor, R.J.	
Coldwell, J.H.	-Stores
*Cotter, M.L.	
Craton, M.I.K.	
*Crouch, R.W.	-Purchasing
Curtis, J.N.	
Deane, G.J.	
Depuit, R.M.	
Doyle, D.A.	-Secretary, Regional Marine Superintendent
Drysdale, A.E.	
Firth, C.	
Hall, E.J.	
Hamilton, K.R.	-Personnel
*Harbar, M.S.	
Jones, K.M.G.	-Secretary, Chief, Management Services
Knapp, B.M.	-Pay and Benefits
Lapp, B.I.	
Lohrmann, B.A.	-Administrative Services
Mathias, A.L.	-Secretary, Ocean Chemistry Division
McKenzie, S.D.	-Secretary, Regional Hydrographer
Mikkelsen, M.L.	
Olauson, E.J.	
Parsons, J.E.	-Finance
Peirson, E.	-Secretary, Ocean Physics Division
Reinstein, H.G.	-Facilities Operation and Maintenance
Sabourin, J.T.	
*Smith, R.M.	
Stevens, I.B.	
*Thomas, C.D.	-Central Registry
Thomson, L.S.C.	-Library
van Dusen, T.S.	-Secretary, Director-General
Wonnacott, D.C.	-Secretary, Ocean Physics Division

*Left during 1979

Commissionaires

Sgt. D.W. Price	Comm. G. Glass	Comm. L. Trerice
Sgt. W.L. Caldwell	Comm. S. McMillen	Comm. J. Quinton
Comm. J. Gessner	Comm. H. Moffat	Comm. T. Osborne
Comm. L. Brown	Comm. A. Samouelle	

Institute of Ocean Sciences

This will be the last report on construction of our new facilities. Most of the major contracts were completed in 1978, and in 1979 we were mainly occupied with clearing up deficiencies and having some troubles corrected during the warranty period. At the time of writing there is only one contract (for an environmental cold room) which has not been completed.

For the majority of the staff the construction process had its finale when, on 28 February, the Governor-General officially opened the Institute. Our former Minister, Mr. Le Blanc and our Deputy Minister, Mr. Tansley, were also present along with representatives from the provincial and municipal governments, and the Capital Regional District. Dr. Stewart hosted the guests, cutting short a trip to Europe to be present for the occasion.

Construction activity at Patricia Bay is, however, about to start again. The original planning for the Institute of Ocean Sciences included another objective to have the private sector in close proximity. During the past year negotiations have been underway with the British Columbia Development Corporation to establish a Marine Technology Centre on part of the site. Agreement has been reached and the Development Corporation anticipates it will be calling tenders for construction early in 1980 with anticipated completion of a first building by mid summer.

Dr. R. W. Stewart and guests at an IOS luncheon following the official opening.

Administration

Perhaps the most significant development in Administration in 1979 was establishment of a regional personnel office in the Institute. Ms. Kathleen Hamilton was appointed Regional Personnel Manager, reporting to the Director-General.

There was a larger than usual turn-over in staff during the year which, coupled with restrictions on hiring, placed additional burdens on the remaining staff. Nevertheless, the routine work in finance, materiel management and records management was completed. The continued development of our materiel inventory system is also worth mention.

The number of people visiting the Institute continued to increase. It is particularly rewarding to note that many of the local schools view a visit to the Institute an important item in their curricula. Many written and verbal compliments to our commissionaires and our scientific and technical staff have been received. A French version of the audio-visual show, with which we start the tours, is now available.

Local press coverage of Institute activities was extensive and generally of a high standard.

Progress has been made in our energy conservation measures. Various changes have been made to procedures and in some hardware in order to reduce energy consumption. A study on the possibility of using solar energy for powering some of the systems has been initiated.

LIBRARY

L.S.C. Thomson - Librarian

C. Firth - Library Clerk

The highlight of 1979 for the Library was the development of a program to put the Library's catalog on the computer. After four years of intermittent discussion and some abortive attempts, the program has metamorphosed into a very usable one. We look forward to spending a considerable proportion of our time in 1980 entering the data and producing a printed catalog.

The Library's budget was decreased and the combined effects of price rises and inflation have resulted in cuts in the journal subscriptions, as well as curtailment in book purchases. We have, however, received increased patronage from outside borrowers, who are very willing to pay for services.

TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

DIRECTOR-GENERAL'S OFFICE

Mann, C.R.

- Scientific Advisory Board, Intergovernmental Oceanographic Commission. (Chairman)
- Advisory Panel on Oceans, Strategic Grants Committee, National Science and Engineering Council. (Chairman)
- Sea Use Council (Canada-U.S.). (Vice-Chairman)
- International Committee for the Exploration of the Sea. (Canadian Delegate)
- Science Council of B.C., Research Evaluation Sub-Committee Ocean and Marine Resources Group.
- Atlantic Research Directors Committee.
- Canadian Oceanographic Delegation to China.
- World Climate Conference. (IOC Representative)

Cornford, A.B.

- Working Committee for Global Investigations of Pollution in the Marine Environment (GIPME). (Canadian Delegate)
- IGOSS (MAPMOPP/MARPOLMON). (Canadian Delegate)
- Institute Management Committee.

HYDROGRAPHIC DIVISION

Ages, A.B.

- Environmental Emergency Working Group, Victoria Zone.
- Technical Committee (DOE), Annacis Island Sewage Treatment.

Bolton, M.

- Hydrographic Committee CIS.
- National Hydrographic Survey Officers' Appraisal Board.
- National Hydrographic Training Committee.
- New Research/Survey Vessel Users Design Committee. (Chairman)
- Pacific Sub-Committee on Oceanography of CCO. (Member)
- Research Ship Scheduling Committee.

Joint DOE/DEMR Guiding Committee of Offshore Surveys.

International Hydrographic Technical Conference (1979). (Chairman)

Survey Engineering Advisory Committee, University of Calgary.

FIG Commission IV. (Canadian Delegate)

Management Committee IOS.

Library Committee IOS. (Chairman)

Curran, T.A.

Electronics Technology Program Advisory Committee, Camosun College.

Galloway, J.L.

Steering Committee for the Establishment of International Shipboard Data Acquisition Standards.

Huggett, W.S.

New Research/Survey Vessel Users Design Committee.

Environmental Emergency Working Group, Victoria Zone.

Regional Hydrographic Survey Officers' Appraisal Board.

Larkin, J.E.

Canadian Institute of Surveying, Victoria Branch. (Secretary)

O'Connor, A.D.

Canadian Institute of Surveying, Victoria Branch. (Past Chairman)

Survey Technology Advisory Committee, BCIT.

Regional Hydrographic Survey Officers' Appraisal Board.

Rapatz, W.J.

B.C. Civil Defense Tsunami Committee.

Ocean Dumping Act. (Inspector)

Richardson, G.E.

Regional Hydrographic Survey Officers' Appraisal Board.

Sandilands, R.W.

Hydrographic Technical Committee, Canadian Institute of Surveying.

The Canadian Surveyor. (Associate Editor (hydrography))

Lighthouse - Canadian Hydrographers Association. (Assistant Editor)

Survey Technology Advisory Committee - Camosun College.

Board of Trustees, Maritime Museum of B.C. (Past Chairman)

International Hydrographic Technical Conference Committee (1979).

Canadian Institute of Surveying, Victoria Branch. (Vice-Chairman)

Canadian Hydrographers Association, Pacific Region. (Executive member)

Regional Hydrographic Survey Officers' Appraisal Board. (Chairman)

Library Committee IOS.

Smith, A.

Sub-committee of CPCGN for Undersea Features.
(Canadian Permanent Committee Geographical Names)

Stephenson, F.E.

IOS Safety Committee.

Watt, J.V.

Electronics Technology Program Advisory Committee, Camosun College.

Wills, R.

Regional Hydrographic Survey Officers' Appraisal Board - Chairman

Regional Committee on Interagency Routing of Navigational Information

Survey Technology Advisory Committee, BCIT

Regional Board, Pacific Region, Estuary Working Group

Wigen, S.O.

International Co-ordination Group for the Tsunami Warning System in the Pacific - National Representative

Canadian Working Group on the Use of Satellites in the Tsunami Warning System - Chairman

Joint Federal/Provincial Tsunami Working Group - Chairman

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Laboratory Safety Committee, Ocean Chemistry. (Chairman)

Institute Safety Committee.

Institute Cafeteria Committee.

Chemical Institute of Canada, Vancouver Island Section. (Secretary)

Organizing Committee - CIC Symposium on "Marine Chemistry into the Eighties".

Macdonald, R.W.

Ocean Dumping Technical Sub-Committee, Pacific Region.

Arctic Petroleum Operators Association/Government Steering Committee on Offshore Drilling Fluid Disposal.

Joint Industry/Government Steering Committee on Problems on Arctic Hydrocarbon Development: Working Group on Ice Scours.

Organizing Committee - CIC Symposium on "Marine Chemistry into the Eighties".

Organizing Committee - NATO Fjord Workshop Symposium.

Thompson, J.A.J.

Institute Safety Committee.

Laboratory Safety Committee - Ocean Chemistry.

Pacific Nuclear Activation Research Association. (Secretary)

Chemical Institute of Canada, Vancouver Island Section. (Vice-Chairman)

Organizing Committee - CIC Symposium on "Marine Chemistry into the Eighties". (Chairman)

Wong, C.S.

Environmental Contaminant Act Advisory Committee, Pacific Region.

NRC Associate Committee on Marine Analytical Standards, Atlantic Regional Laboratory.

CO_2 Standardization Committee - GEOSECS.

Organizing Committee, NATO Advanced Research Institute on " Accurate Measurement of Trace Metals in Sea Water". (Chairman)

Local Organizer, Symposium on Controlled Experiments, August, 1980.

Institute Management Committee.

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.

University of Victoria. (Honorary Professor)

Royal Ontario Museum. (Research Associate)

North American Benthological Society. (President-Elect)

American Society Limnology and Oceanography.

Regional Ocean Dumping Advisory Committee. (OAS Representative)

Science Subvention Assessment. (OAS Representative)

Standards Council of Canada - ISO/TC/147/ScS Member.

First International Aquatic Oligochaete Biology Symposium. (Chairman and Proceedings Editor)

Rawson Foundation. (Fellow)

European Marine Biological Symposium (Helgoland). (Session Chairman)

University of Hamburg, Zoological Institute and Museum. (Visiting Investigator)

University of Victoria. (Graduate Student Committees (3))

Institute Management Committee.

Denman, K.L.

Canadian Marine Sciences Delegation, China.

Canadian Meteorological and Oceanographic Society. (Chairman, Citations Committee)

American Society Limnology and Oceanography. (Member, Nominations Committee)

Herlinveaux, R.H.

Regional Ocean Dumping Advisory Committee (Arctic).

Oil Spill Emergency Team. (OAS Representative)

Arctic Waters Advisory Committee. (OAS (Alt.) Representative)

Mackas, D.

University of Victoria. (Adjunct Assistant Professor)

OCEAN PHYSICS DIVISION

Bell, W.H.

RODAC Technical Sub-Committee.

Farmer, D.M.

Babine Lake Steering Committee.

AGU Estuarine Coastal Oceanography Committee.

Garrett, J.F.

Committee of Participants in the Southern Hemisphere Drifting Buoy System for the FGGE. (Chairman)

Giovando, L.F.

Joint Working Committee Lower Fraser River Environmental Monitoring.

B.C. Coastal Zone Resource Sub-Committee.

Roberts Bank Environmental Sub-Committee.

Gower, J.F.R.

Canadian Advisory Committee on Remote Sensing, Working Group on Oceanography. (Chairman)

NAIA Seasat Synthetic Aperture Radar Experiment Team.

IUCRM Inter Union Commission on Radio Meteorology.

SCOR representative to COSPAR.

Henry, R.F.

University of Victoria Co-operative Education Advisory Council. (IOS Representative (since Oct.1979))

Lake, R.A.

Arctic Marine Oilspill Program (AMOP) - Management Committee.

Arctic Water Advisory Committee (AWAC). (Alternate Representative)

Lewis, E.L.

UNESCO/SCOR/IAPSO/ICES Joint Panel of Experts on Oceanographic Tables and Standards (SCOR W.G. 10).

SCOR/IAPSO Working Group 51 - Evaluation of CTD Data.

SCOR Working Group 58 - Arctic Ocean Heat Budget.

Canadian Committee on Oceanography Panel on Ice - Arctic Oceanography Sub-Committee.

Marine Science Communications - Editorial Advisory Board.

Canadian National Committee for SCOR.

Arctic Water Advisory Committee (AWAC).

Murty, T.S.

IUGG Tsunami Committee. (Canadian representative and Vice-Chairman)

Canadian Meteorological and Oceanographic Society (CMOS). (Recording Secretary (until June 1979))

Journal of Marine Geodesy. (Associate Editor)

University of Quebec at Rimouski. (Honorary Director of Research)

U.S. Marine Technology Society Panel. (Tsunami expert)

Canadian Working Group on the Use of Satellites in the Tsunami Warning System.

DFO Advisory Board on Scientific Information and Publications. (IOS representative)

Smiley, B.D.

Fate and Effects Working Group of Advisory Group on Research and Development and Member (EPS-AGRAD) Petrocan Environmental Advisory Committee.

Tabata, S.

Ocean Climate Panel of Working Group 48 of the Scientific Committee on Oceanic Research (SCOR).

Integrated Global Ocean Systems (IGOSS). Sub Group on Scientific Matters.

Organizing Committee of the 13th Canadian Meteorological and Oceanographic Congress (disbanded November 1979).

Thomson, R.E.

RSCC Committee on Burrard Inlet Floating Drydock.

Atmosphere-Ocean. (Associate Editor)

Canadian Meteorological and Oceanographic Society, Vancouver Island Centre. (Treasurer)

B.C.-Yukon Inuit Regional Committee of the Professional Institute. (Victoria Representative)

COMPUTING SERVICES

Teng, K.

Organizing Committee for CIPS '80 National Computer Conference. (Co-Secretary)

Johns, R.E.

Organizing Committee for CIPS '80 National Computer Conference. (Treasurer)

Canadian Information Processing Society, Victoria Section. (Treasurer)

SHIP DIVISION

Geldart, E.N.

Pacific Regional Resource/Survey Vessel Committee. (Secretary)

CONTRACTS AWARDED DURING 1979/80

Oceanographic Data Collection on the Fraser River Estuary J. Bruce, Sidney, B.C.	6,000
Preparation for library catalogue of scientific reports concerning Tsunami tidal waves A. Kriz, Victoria, B.C.	2,744
Feasibility examination of alternative electronic operating systems for a turbulent velocity measurement probe Cardec Engineering Ltd., Victoria, B.C.	3,700
Development of a public information program on the scientific programs within the Institute of Ocean Sciences Taiga Management Ltd., Victoria, B.C.	8,900
Numerical modelling studies of the estuarine circulation in the Strait of Georgia System - Part I University of British Columbia, Vancouver, B.C.	10,000
Processing of physical oceanographic data as returned by oceanographic observers from the weathership QUADRA and VANCOUVER Interact Computing Services, Victoria, B.C.	3,809
Study to determine the tidal residual circulation in the Juan de Fuca and Georgia Strait system Beak Consultants, Vancouver, B.C.	151,741
Analysis of offshore oceanographic data from Line P experiment B. Choo, Victoria, B.C.	3,500
Design and write a data storage and processing computer program for the digitization of tsunami traces appearing on tidal marigrams B. Waring, Victoria, B.C.	1,500
Development of computer programs for ocean mixing Apocalypse Enterprises Ltd., Victoria, B.C.	19,436
Development of computer programs for remote sensing Apocalypse Enterprises Ltd., Victoria, B.C.	9,968
Continuing support for the West Coast Ocean Dumping Program Dobrocky Seatech Ltd.	9,000
Development of computer programs for fluid problems in fjords and coastal waters CPRO Computing Enterprises Inc., Victoria, B.C.	22,500

Development of computer programs for Tides & Currents CPRO Computing Enterprises Inc., Victoria, B.C.	24,957
Data preparation and drafting of diagrams for scientific publications C. Wallace, Sidney, B.C.	3,037
Study and analysis of plankton samples from B.C. coastal waters G. Gardner, Brentwood Bay, B.C.	5,450
Identification of marine oligochaeta obtained from the Strait of Juan de Fuca H.R. Baker, Victoria, B.C.	2,000
Preparation of an index of data collected during the Kitimat oceanographic study Dobrocky Seatech Ltd., Victoria, B.C.	4,441
Carry out simultaneous deployment of three controlled ecosystem enclosures J&J Divers, Victoria, B.C.	975
Analysis of dissolved nutrients in seawater Seakem Oceanography Ltd., Sidney, B.C.	19,575
Study of remote sensing of open ocean chlorophyll and temperature Seakem Oceanography Ltd., Sidney, B.C.	56,917
Assessment of mussel health and surface sediment concentrations of polycyclic hydrocarbons in Alberni Inlet Seakem Oceanography Ltd., Sidney, B.C.	15,953
Provision of oceanographic support to the Institute of Ocean Sciences Dobrocky Seatech Ltd., Victoria, B.C.	20,000
Provision of support to IOS to carry out oceanographic programs Bastion City Charters Ltd., Nanaimo, B.C.	10,000
Analysis of seawater and air samples from weatherships Seakem Oceanography Ltd., Sidney, B.C.	40,000
Continuing development of alternative electronic operating systems for a turbulent velocity measurement probe Cardec Engineering, Victoria, B.C.	5,500
Review of oceanographic data relating to ocean dumping in the Prince Rupert area EVS Consultants, Vancouver, B.C.	14,212

Analysis of data relating to dumpsite colonization and temporal changes in benthic communities in Alberni Inlet EVS Consultants Ltd., Vancouver, B.C.	6,974
Dissolved oxygen study of deep waters in the inner basin of Alberni Inlet Dobrocky Seatech Ltd., Victoria, B.C.	114,726
Analysis of B.C. coastal water data from the Dept. of Fisheries and Oceans colour spectrometer Seakem Oceanography Ltd., Victoria, B.C.	5,587
Analysis of oceanographic data collected by the weatherships and selected shore stations D. Ramsden, Victoria, B.C.	6,825
Documentation and data quality control of First GARP Global Experiment T. Garrett, Victoria, B.C.	8,684
Compilation of Pacific Region data for data acquisition and management plan report P.W. Nasmyth, Victoria, B.C.	380
Development, construction and testing of a scientific research system for in situ chemical studies Case Existological Labs Ltd., Victoria, B.C.	272,698
Development and logistics planning and coordination for GARP First Global Experiment Beak Consultants, Vancouver, B.C.	113,819
Feasibility study using ships of opportunity to collect physical and biological oceanographic data Seakem Oceanography Ltd., Sidney, B.C.	22,373
Development of microprocessor based acoustic navigation system for surveying from a small submarine Mesotech Systems Ltd., Vancouver, B.C.	26,415
Modification of the Department of Fisheries and Oceans submersible PISCES IV International Hydrodynamics, North Vancouver, B.C.	1,500
Collection of zooplankton samples aboard the CSS *Vector* H. Sefton, Victoria, B.C.	1,556
Laboratory study of behaviour of oil and gas particles in salt water relating to deep oil well blowouts University of Calgary	24,043

Collection and supply of hydrographic field data for corrections and updating navigational charts and sailing directions Coast Pilot Ltd., Sidney, B.C.	34,000
Oceanographic observations aboard CCGS QUADRA G. Jewsbury, Victoria, B.C.	6,014
Preparation of materials for Beaufort Sea technical and scientific overview reports Hoot Productions, Victoria, B.C.	13,050
Oceanic water properties sampling and measurement program aboard CCGS QUADRA Seakem Oceanography Ltd., Sidney, B.C.	8,895
Study on the occurrence and nature of tin and its organic derivative in sewage wastes, industrial effluents, fresh and saline waters of southwest B.C. University of B.C., Vancouver, B.C.	21,346
Biological and oceanographic research support to IOS University of Victoria, Victoria, B.C.	2,000
Analysis of dissolved nutrients in seawater Seakem Oceanography Ltd., Sidney, B.C.	3,930
Historical study of tsunami data extraction M. Lane, Victoria, B.C.	3,000
Lethal and sublethal tolerances of aquatic oligochaetes with reference to their use as biological indicators of pollution EVS Consultants, Vancouver, B.C.	140,000
Preparation of a report on Ocean Weather Station P particulate organic carbon data K. Iseki, Sidney, B.C.	2,500
Analysis of seawater and air samples from weathership Seakem Oceanography Ltd., Sidney, B.C.	15,000
Study of pingo-like features detected in the Beaufort Sea Coast Pilot Ltd., Sidney, B.C.	6,982
Statistical analyses of pingo-like features in the Beaufort Sea Barrodale Computing Services Ltd., Victoria, B.C.	3,700
Development of computer programs for tides and currents CPRO Computing Enterprises Inc., Victoria, B.C. (amendment)	11,535

Study on the acoustic target strength of pingo-like features found in the Beaufort Sea Geomarine Associates Ltd., Halifax, N.S.	4,000
Study on behaviour pathways, residence time and toxicity of Pentachlorophenol in the marine environment Dobrocky Seatech Ltd., Victoria, B.C.	29,546
Study on applying side-tow techniques for hydrographic surveys B.C. Research, Vancouver, B.C.	10,000
Study of digital terrain modelling to hydrographic survey charting activities Barrodale Computing Services Ltd., Victoria, B.C.	3,940
Pingo correlation and prediction study J. Shearer, Ottawa, Ontario	12,371
Development of hydrographic resource allocation package Coast Projects Ltd., Victoria, B.C.	9,920
Amendment to feasibility study using ships of opportunity to collect physical and biological oceanographic data Seakem Oceanography Ltd., Sidney, B.C.	22,373
Amendment to the development of a microprocessor based, precision acoustic navigation system for surveying from a small submersible Mesotech Systems Ltd., North Vancouver, B.C.	26,415
Oceanographic observations aboard CCGS QUADRA G. Jewsbury, Victoria, B.C.	6,014
Oceanic water properties sampling and measurement program aboard CCGS QUADRA (amended) Seakem Oceanography Ltd., Sidney, B.C.	88,950
Preparation of a manual containing detailed descriptions of the programs used to process STD and hydro data collected by weatherships Interact Computing Services Ltd., Victoria, B.C.	6,000
Processing of oceanographic data from Alberni Inlet Interact Computing Services Ltd., Victoria, B.C.	4,980
Feasibility study for a wide swath sonar system Mesotech Systems Ltd., North Vancouver, B.C.	21,153
Study on the migration of mercury from sediments Chemex Labs Ltd.	29,895

Evaluation of sonar equipment and techniques for applications in the Beaufort Sea Huntec (70') Ltd., Scarborough, Ont.	34,000
Study on applying side-tow techniques to hydrographic surveys B.C. Research, Vancouver, B.C.	10,000
Pingo correlation and prediction study Geomarine Assn., St.Johns, Nfld., and S. Shearer, Ottawa, Ont.	4,000
Analysis of calibration samples for ocean ecology profiler A. Sinclair	3,925
Drafting and photographic services Techni-Graphics	1,900

PUBLICATIONS

Institute of Ocean Sciences, Patricia Bay, 1979 Annual Report

PACIFIC MARINE SCIENCE REPORTS

PMSR 79-1	
Miyake, M.	Oceanographic observations at Ocean Station P during mixed layer experiment August 1, 1978. Volume 84-B.
PMSR 79-2	
Miyake, M.	Oceanographic observations at stations along the triangular grids during the mixed layer experiment August 1, 1978. Volume 84-C.
PMSR 79-3	
Mortimer, A.R.	A Loran-C calibration, the West Canadian chain cycle selection tests.
PMSR 79-4	
Brinkhurst, R.O.	Distribution of aquatic oligochaeta in some habitats of lower British Columbia.
PMSR 79-5	
Byers, S.C. and R.O. Brinkhurst, Eds.	Report on ocean dumping R and D, Pacific Region, Fisheries and Environment Canada 1977-78.
PMSR 79-6	Oceanographic observations at Ocean Station P 16 June - 2 August 1978. Volume 92.
PMSR 79-7	Oceanographic observations at Ocean Station P 28 July - 13 September 1978. Volume 93.
PMSR 79-8	Oceanographic observations at Ocean Station P 8 September - 26 October 1978. Volume 94.
PMSR 79-9	Oceanographic observations at Ocean Station P 20 October - 6 December 1978. Volume 95.
PMSR 79-10	Oceanographic observations at Ocean Station P 1 December 1978 - 10 January 1979. Volume 96.
PMSR 79-11	
Murty, T.S. and R.E. Brown	The submarine slide of 27 April, 1975 in Kitimat Inlet and the water waves that accompanied it.

PMSR 79-12 (Pts. I & II)

Coastal Zone Oceanography Section	Oceanographic observations in Knight Inlet, B.C. Volume I: Salinity/temperature profile Part I: 1977, Part II: 1978.

PMSR 79-13

Crean, P.B., M. Miyake and W.S. Huggett	Data report of STD observations Volume 1: Strait of Juan de Fuca 1973.

PMSR 79-14

Ages, A.	Salinity intrusion in the Fraser River: Salinity, temperature and current observations, 1976, 1977.

PMSR 79-15

Foreman, M.G.G. and R.F. Henry	Tidal analysis based on high and low water observations.

PMSR 79-16

Herlinveaux, R.H.	Oceanographic observations in Robeson Channel, N.W.T. 1971.

PMSR 79-17

Thompson, J.A.J., D.W. Paton and M. Timmons	Copper and zinc in sediments of Georgia Strait, B.C. in the vicinity of Texada Mine.

PMSR 79-18

Byers, S.C. and R.O. Brinkhurst, Eds.	Report on ocean dumping R and D Pacific Region Department of Fisheries and Oceans 1978-1979.

PMSR 79-19

Tabata, S. and P.M. Kimber	Satellite observations of sea surface temperature patterns off the Pacific coast of Canada.

PMSR 79-20

Bell, W.H.	A three-dimensional subsurface mooring model.

PMSR 79-21 (Pts. I, II, III, IV)

Coastal Zone Oceanography Section	Salinity/temperature profiles in Haro Strait, B.C. Part I: April-July 1976, Part II: September-October 1976, Part III: November-December 1976, Part IV: January-April 1977.

CONTRACTOR REPORT SERIES

CRS 79-1

Lea, Brian N., Dobrocky Seatech Ltd.	Development, testing and deployment of moorings for use in areas of negligible horizontal magnetic field.

CRS 79-2

Conlan, K.E., S.C. Byers, Ed., Dobrocky Seatech Ltd.	The biological effects of ocean dumping: a selected, annotated bibliography.

CRS 79-3

Beak Consultants Ltd., Vancouver, B.C.	An examination of the variability of upwelling on the west coast of Vancouver Island and its relationship to the flushing of Alberni Inlet.

OTHER PUBLICATIONS - 1979

Ages, A.B. 1979. Oil spill modelling in British Columbia: In: Oil Spill Modelling, Proceedings of a Workshop. D. Mackay, ed. Toronto, University of Toronto, 1979. pp.143-149.

Baker, H.R. and C. Erseus. 1979. Peosidrilus biprostatus n.g.n. sp. a marine tubificid (oligochaeta) from the eastern United States. Proc. Biol. Soc. Wash. 92: 505-509.

Bell, W.H. 1979. The influence of turbulence on drag. Ocean Engng. 6 329-340.

Brinkhurst, R.O. 1979. A new species of Limnodrilus (Oligochaeta, Tubificidae) from Jamaica. Proc. Biol. Soc., Wash. 92: 42-44.

Brinkhurst, R.O. 1979. On the types in the genus Peloscolex Leidy Oligochaeta, Tubificidae). Proc. Biol. Soc. Wash. 92: 677-681.

Brinkhurst, R.O. and M.J. Austin. 1979. Assimulation by Aquatic Oligochaeta. Int. Rev. Ges. Hydrobiol. 63: 245-250.

Brinkhurst, R.O. and H.R. Baker. 1979. A review of the marine Tubificidae (Oligochaeta) of North America. Can. J. Zool. 57: 1553-1569.

Brinkhurst, R.O. and W. Fulton. 1979. Some aquatic Oligochaeta from Tasmania. Rec. Queen Victoria Mus. 64 :1-8.

Crawford, W.R. 1979. Pressure measurements on seamounts in the North Pacific. Proc. Symposium on Lond Waves in the Ocean. Manuscript Report Series No.53, Marine Sciences Directorate, Ottawa.

Crawford, W.R. and T.R. Osborn. 1979. Microstructure measurements in the Atlantic Equatorial Undercurrent during GATE. Deep-Sea Res., GATE supplement II to 26: 285-308.

Crawford, W.R. and T.R. Osborn. 1979. Energetics of the Atlantic Equatorial Undercurrent. Deep-Sea Res., GATE supplement II to 26: 309-324.

Cretney, W.J., W.D. Jamieson, M.D. Mackinnon and D.R. Green. 1979. A GC/MS study of the total fluorescence method for the analysis of polynuclear aromatic hydrocarbons in sea water. In: Proc. of the 27th Annual Conference on Mass Spectrometry and Allied Topics, American Society for Mass Spectrometry. (An extended abstract.)

Cretney, W.J., E.J. Carpenter, B.F. Morris and R.K. Swanson. 1979. Litter. Proc. of a Workshop on Scientific Problems Relating to Ocean Pollution, Estes Park, Colorado, July 10-14, 1978: 51-68.

Farmer, D.M. and H.E. Huppert. 1979. The oceanography of fjords. Nature 280: 273-274.

Farmer, D.M. and J.D. Smith. 1979. Internal waves during GATE. Deep-Sea Res. 26A: 347-350.

Freeland, H.J. 1979. Tidal analysis and the energetics of a deep stratified inlet. Proc. of the International Symp. on Long Waves in the Ocean, Ottawa.

Foreman, M.G.G., L.M. Delves, I. Barrodale and R.F. Henry. 1979. On the use of the Proudman-Heaps Tidal Theorem. Geophysical J. of the Royl. Astr. Soc. (In press).

Galloway, J.L. and R.C. Teichrob. 1979. SCRIBE data acquisition in a submersible. Proc. OCEANS '79, San Diego. pp. 772-776.

Gargett, A.E. 1979. Turbulence measurements through a train of breaking internal waves in Knight Inlet, British Columbia. In Fjord Oceanography. Plenum Pr. (In press.)

Gargett, A.E. and T.R. Osborn. 1979. Dissipation measurements from the Fine and Microstructure Experiment. Univ. of B.C. Inst. Oceanography Manuscript report no. 33. Vancouver.

Gargett, A.E. and T.R. Osborn. 1979. Surface mixing layers in the Sargasso Sea. J. Phys. Oceanogr. 9: 6.

Gonzales, F.E., R.C. Beal, W.E. Brown, J.F.R. Gower, D. Lichy, D.B. Ross, C.L. Reifenach and R.A. Shuchman. 1979. SEASAT synthetic aperture radar ocean wave detection capabilities. Science 204: 1418.

Gower, J.F.R. 1979. The computation of ocean wave heights from GEOS-3 satellite radar altimeter data. Rem. Sensing Envir. 8: 97.

Gower, J.F.R. and B.A. Hughes. 1979. Radar and ship observations of coastal sea surface roughness patterns in the Gulf of Georgia. Paper presented at 13th Symposium on Remote Sensing of Environment, Ann Arbor, Mich. Apr. 1979.

Herman, A.W. and I.L. Denman. 1979. Intrusions and vertical mixing at the shelf/slope water front south of Nova Scotia. J. Fish. Res. Board Can. 36: 1445-1453.

Holbrook, J., S. Frisch and A.B. Ages. 1979. Coastal forcing in the Strait of Juan de Fuca. AGU Fall 1979. (In press.)

Lewis, E.L. 1979. Some possible effects of arctic industrial development on the marine environment. Proc. 5th Int. Conf. on Port & Ocean Engineering Under Arctic Conditions. Trondheim, Norway. pp. 369-392.

Lewis, E.L. and N.P. Fofonoff. 1979. Notice to oceanographers, a practical salinity scale. Published in EOS; J. Phy. Oceanog.; Deep Sea Res.; Oceanologica (in Russian); J. Oc. Soc. Japan (in Japanese); etc.

Mackas, D.L. and C.M. Boyd. 1979. Spectral analysis of zooplankton spatial heterogeneity. Science 204: 62-64.

Milne, A.R. and R.H. Herlinveaux. 1979. Crude oil in cold water. Beaufort Sea Project Overview report. Victoria, Beaufort Sea Project.

Mortimer, A.R. 1979. Comments on the Internav Loran-C Co-ordinate Converter Unit (CC-2). Lighthouse, edition no. 20: 22-24.

Murty, T.S. 1979. A mathematical model for pre-boiling convection in a geyser vent. Amer. J. Sci. (In press).

Murty, T.S. 1979. Contribution of physical oceanographic processes to sea level variation. Proc.of the International Conference on Marine Geodesy and Navigation, New Orleans, Oct.10-12, 1979. Marine Technology Society. (In press).

Murty, T.S. 1979. Submarine slide-generated water waves in Kitimat Inlet, British Columbia. J.of Geophys.Res. (In press).

Murty, T.S., F.G. Barber, and J.D. Taylor. 1979. Role of advective terms in tidally generated residual circulation. Limn. and Oceanogr. (In press).

Murty, T.S., M.I. El-Sabh, and J.M. Briand. 1979. Storm surge amplitudes in the St.Lawrence estuary. Lighthouse. (In press).

Murty, T.S. and H.G. Loomis. 1979. A new tsunami magnitude scale. Newsletter of the International Tsunami Information Center, 12(2), 19pp.

Murty, T.S. and M.C. Rasmussen. 1979. Plans for numerical modelling of circulation associated with sills in the Canadian Arctic Archipelago. Proc.of an Arctic Physical Oceanography Workshop, Oct.10-11, 1978, Inst.of Ocean Sciences, Patricia Bay, 18pp.

Murty, T.S. and M.C. Rasmussen. 1979. Tidally-forced stratified flow over sills. Proc.of the Fjord Oceanographic Workshop, Victoria, B.C., June 4-8, 1979. Sponsored by N.A.T.O. as an Advanced Research Institute. (In press).

Sandilands, R.W. 1979. I am become a name (West Coast toponomy). Canoma 5(1): 12-15.

Sandilands, R.W. 1979. Whose name was writ in water: (A short history of the *Challenger* Expedition). Lighthouse, Edition no. 19: 1-6.

Sandilands, R.W. 1979. Charlie Golf Foxtrot Quebec: (A history of the CSS *William J. Stewart*). Lighthouse, Edition no. 20: 1-3.

Smiley, B.D. and A.R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards. Sidney, Institute of Ocean Sciences, Patricia Bay. 47p.

Tabata, S. 1979. A need for improved quality of sea-surface temperature data from the world oceans. Intergovernmental Oceanographic Commission Workshop, Report no.17 - supplement: 481-492.

Tabata, S. 1979. On the variability of water properties in the surface mixed layer at Station P. Limnol. and Oceanogr. 24(1): 158-163.

Wigen, S.O. and M.G. Spaeth. 1979. Report on the use of satellites in the Tsunami Warning System. Tsunami Newsletter 12(2). International Tsunami Information Center.

Wong, C.S., K.S. Johnson and R.M. Pytkowicz. 1979. Biological production and the exchange of oxygen and CO_2 across the sea surface in Stuart Channel, B.C. Limnol. and Oceanogr. 24(3), 474-482.

Wong, C.S. 1979. Carbon input to the atmosphere from forest fires. Science, 204, 209-210.

Woods, M.V. 1979. The Mini-Ranger Data Processor/Automated Positioning System - A useful tool for positioning sweeps. Lighthouse, no.19, 7-10.

Yorath, C.J., B.D. Bornhold and R.E. Thomson. 1979. Oscillation megaripples on the northeast Pacific continental shelf. J.Mar.Geol.31: 45-58.

PERMANENT STAFF 1979

DIRECTOR GENERAL

*Stewart, R.W.; B.Sc., M.Sc. (Queen's), Ph.D. (Cantab), FRSC, FRS, D.Sc. (McGill), LL.D. (Dalhousie).

Mann, C.R.; B.Sc., M.Sc. (N.Z.), Ph.D. (Brit. Col.), D.Eng. (N.S.Tech), FRSC.

ASSISTANT TO DIRECTOR GENERAL

Cornford, A.B.; B.Sc. (McMaster), Ph.D. (Brit. Col.) - Head, Program Analysis & Liaison

MANAGEMENT SERVICES DIVISION

Todd, N.A.; B.Sc.(Glasgow), M.A. (Carleton) - Chief of Division

*Aanhout, D.L. van
Batchelor, R.J.
Coldwell, J.H.
*Cotter, M.L.
Craton, M.I.K.
*Crouch, R.W.
Curtis, J.N.
Deane, G.J.
Depuit, R.M.
Doyle, D.A.
Drysdale, A.E.
Firth, C.
Hall, E.J.
Hamilton, K.R.; B.A. (Brit. Col.)
*Harbar, M.S.
*Jones, K.M.G.
Knapp. B.M.
Lapp, B.I.; B.A. (Victoria)
Lohrmann, B.A.; B.Sc., M.Sc. (Guelph)
Mathias, A.L.
McKenzie, S.D.
Mikkelsen, M.L.
Olauson, E.J.
Parsons, J.E.
Peirson, E.
Reinstein, H.G.
Sabourin, J.T.
*Smith, R.M.
Stevens, I.B.; CIMA (McMaster)
*Thomas, C.D.
Thomson, L.S.C.; B.A. (Saskatchewan), B.L.S. (Brit. Col.)
Van Dusen, T.S.
Wonnacott, D.C.

Commissionaires

Sgt. D.W. Price
Sgt. W.L. Caldwell
Comm. J. Gessner
Comm. L. Brown
Comm. G. Glass
Comm. S. McMillen
Comm. H. Moffat
Comm. A. Samouelle
Comm. L. Trerice
Comm. J. Quinton
Comm. T. Osborne

*Left during 1979

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

Ages, A.B.; B.A.Sc., M.A.Sc. (Brit.Col.), P. Eng.
Bell, R.D.
Brown, R.E.
Browning, P.C.
Chan, G.L.
Coldham, F.A.
Crawford, W.R.; B.Sc., M.A.Sc. (Waterloo), Ph.D. (Brit.Col.)
Crowley, J.V.
Crowther, W.S.
***Curran, T.A.; B.A.Sc. (EE) (Brit.Col.), P.Eng.
Czotter, K.L.; Dip. BCIT
D'Aoust, A.J.; P.Eng. (UNB)
Dobson, D.C.
Dorosh, L.W.; Dip. BCIT
Earl, E.L.P.
***Eaton, G.H.; Dip. BCIT
Ellison, G.
Farmer, M.
Fisher, D.L.
Galloway, J.L.; B.A.Sc. (EE) M.A.Sc.(EE) (Brit.Col.), P.Eng.
Gould, J.
***Gregson, D.J.; Dip. BCIT
Harris, W.J.
Harrison, D.
Hermiston, F.V.
Hinds, E.W.; Dip. BCIT
Hohl, M.
Hollinger, C.; Dip. BCIT
Holman, K.R.
*Huggett, S.
Huggett, W.S.; Master, (FG)
Johnson, B.A.; Dip. BCIT
Josephson, K.G.
**Kenny, B.
Korhonen, R.K.
Kynoch, B.D.
Larkin, J.G.; B.Sc. (P.E.I.)
**Lee, K.S.
Loschiavo, R.; Dip. BCIT
Lusk, B.M.; Master, (350 T)
Lyon, A.G.
Ma, A.C.; B.Sc. (Victoria)
May, R.I.D.; Dip. BCIT
**Mikkelsen, M.
Milner, P.R.; Dip. BCIT
Moody, A.E.
Mortimer, A.R.; Master, (FG), B.Sc. (Victoria)
*Morton, P.A.; A.O.C.A.
Muse, R.A.; Trade Cert. CAF
*Nielson, G.C.
O'Connor, A.D.; Mate (HT) (U.K.), Master (350 T)
Osborne, M.
*Parker, R.N.S.
Patton, M.M.
Philp, A.R.
Pickell, L.M.
Pierce, R.A.
Popejoy, R.D.
Preece, M.L.; Dip. BCIT
Rapatz, W.J.; B.Sc. (Victoria)
Raymond, A.R.; Dip. (Algonquin College)
Richardson, G.E.
Ross, A.D.; CC (Ontario Inst. of Chartered Cartographers)
Said, N.A.
Sandilands, R.W.; Lt. (H) RN (Ret'd.)
Sargent, E.D.; Dip. BCIT
Schoenrank, R.U.; B.Sc. (Victoria)
Smedley, A.J.; Lcdr. RCN (Ret'd.)
Smith, A.; Master (FG)
Smith, G.R.; B.A.Sc. (ME) (Brit.Col.), P.Eng.
Steeples, J.; Cert. Mech. Eng. (Edinburgh)
**St. Gelais, J.
Stephenson, F.E.; B.Sc. (Victoria)
**Stone, M.; Dip. (Camosun Coll.)
Tamasi, C.R.; Dip. BCIT
Taylor, R.G.
Taylor, W.R.; Dip. RCC
Thompson, L.G.
Van Duin, W.P.; Dip. BCIT
Vosburgh, J.A.; Dip. BCIT
Wakefield, L.M.
Ward, M.M.; Dip. BCIT, B.A. (Geog.)
Watt, B.M.
Watt, J.W.; B.A.Sc. (EE) (Brit.Col.), P. Eng.
Whincup, G.

Wigen, S.O.; B.A.Sc. (Brit.Col.), P.Eng.
*Wills, R.; Master (FG)
Wood, D.J.; Dip. BCIT
Woods, M.V.; Dip. BCIT
Woodward, M.J.; B.Sc. (Victoria), M.Sc. (Toronto)

* Left during 1979
** Joined during 1979
*** Educational leave

COMPUTING SERVICES

Teng, K.; B.A.Sc., M.A. (Brit.Col.) - Head of Division

Butcher, J.W.; B.Sc. (Victoria) M.Sc. (Toronto)
Douglas, A.N.; B.Sc. (Victoria)
Foreman, M.G.; B.Sc. (Queen's), M.Sc. (Victoria)
Johns, R.E.; B.Sc. (Victoria) M.Sc. (Brit.Col.)
Orass, S.R.; B.A.Sc., M.A.Sc. (Brit.Col.)
Page, J.S.; B.Sc. (Brit.Col.)
Richards, P.J.; B.Sc. (Brit.Col.)
Smith, D.B.; B.Sc. (Victoria)
Wharton, A.H.; B.Sc. (Victoria)
Woollard, A.L.; B.Sc. (Victoria)

OCEAN CHEMISTRY DIVISION

Wong, C.S.; B.Sc., M.Sc. (Hong Kong), Ph.D. (Scripps), Dip.Mar.Sc. (UNESCO), MCIC, FRIC - Head of Division

Bellegay, R.D.; Dip. NAIT, Ass.Deg.in Oceanography (Shoreline Community College, Seattle)
Cretney, W.J.; B.Sc., Ph.D. (Brit.Col.)
Johnson, W.K.; Dip. BCIT
Macdonald, D.M.; B.A.Sc. (Brit.Col.)
Macdonald, R.W.; B.Sc., Ph.D. (Dalhousie)
McLaughlin, F.A.; B.Sc. (Victoria)
Munro, P.S.; B.Sc. (Queen's)
Paton, D.W.; B.Sc. (Brit.Col.)
Soutar, T.J.; Dip. BCIT
Thompson, J.A.J.; B.Sc. (McMaster), Ph.D. (Alberta)
Whitney, F.A.; B.Sc. (Brit.Col.)

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.; D.Sc. (London) - Head of Division

Austin, M.J.; B.Sc. (Brit.Col.)
Denman, K.L.; B.Sc. (Calgary), Ph.D. (Brit.Col.)
Herlinveaux, R.H.
Hill, S.H.; B.Sc. (Brit.Col.), M.Sc. (Victoria)
Mackas, D.L.; B.S., M.S. (Washington), Ph.D. (Dalhousie)

OCEAN PHYSICS DIVISION

*Nasmyth, P.W.; B.A.Sc., M.A., Ph.D. (Brit.Col.) - Chief of Division

Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.) - Acting Head of Division

Bell, W.H.; B.A.Sc. (Brit.Col.), M.Sc. (Hawaii), P.Eng.
Bigham, R.W.
Chase, G.W.; Dip. BCIT
Cooke, R.A.; Dip. RCC
Crean, P.B.; B.Sc. (Dublin), M.A.Sc. (Toronto), Ph.D. (Liverpool)
de Jong, C.
Farmer, D.M.; B.Com., M.Sc. (McGill) Ph.D. (Brit.Col.)
Freeland, H.J.; B.A. (Essex), Ph.D. (Dalhousie)
Gargett, A.E.; B.Sc. (Manitoba), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D. (Cantab)
Henry, R.F.; B.Sc. (Edinburgh), Ph.D. (Cantab)
Herlinveaux, R.H.
Johnston, P.
Kamitakahara, G.R.; B.Sc. (Toronto)
Koppel, A.W.
Kimber, P.M.
Kuwahara, L.S.C.; B.Sc. (Brit.Col.)
Lake, R.A.; B.Sc. (Brit.Col.), M.Sc. (Washington)
Lewis, E.L.; B.Sc., M.Sc., Ph.D. (London)

*Left during 1979

Linguanti, J.; B.Sc. (Victoria)
Love, J.
McNeill. J.M.
Meikle, J.H.
Melling, H.; B.Sc., M.Sc., Ph.D. (Toronto)
*Milne, A.R.; B.A.Sc. (Toronto) M.Sc. (McGill)
Minkley, B.G.; Dip. BCIT
Miyake, M.; B.S.(EE) (Drexel), M.S., Ph.D. (Washington)
Moorhouse, S.W.
Murty, T.S.; B.Sc., M.Sc. (Andhra), M.S., Ph.D. (Chicago)
Perkin, R.G.; B.A.Sc., M.Sc. (Brit. Col.)
Richards, D.L.
Sieberg, D.G.; Dip. VVI
Smiley, B.D.; B.Sc., M.Sc. (Alberta)
Spearing, L.A.F.; B.Sc. (Brit.Col.)
Stickland, J.A.
Stucchi, D.J.; B.A.Sc. (York), M.Sc. (Dalhousie)
Sudar, R.B.; B.A.Sc. (Toronto)
Tabata, S.; B.A., M.A. (Brit.Col.), D.Sc. (Tokyo)
Teichrob, R.C.; Dip. BCIT
Thomson, R.E.; B.Sc., Ph.D. (Brit. (Col.)
Topham, D.R.; D.L.C., D.C.A.E., Ph.D. (Loughborough)
Wallace, J.S.

SHIP DIVISION

Geldart, E.N.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Regional Marine Superintendent
*Norton, N.St.C.	Master F.G.; Assistant Marine Superintendent (Deck)
Parkinson, R.W.	Engineer 1st Class Combined; Assistant Marine Superintendent (Engineering), M.I.M.E.
*Henderson, J.D.	Engineer 2nd Class Steam; Depot Supervisor

Smith, F.V.	Marine and Industrial Electrician; Depot Supervisor
Redman, D.J.	Design Draftsman; O.N.C.
P. Periera	Relief Chief Engineer, 1st Class Motor
J. Orr-Hood	Relief Senior Engineer; 3rd Class Motor
Bishop, S.O.	Master H.T.; Relief Chief Officer

CSS *PARIZEAU*

Chamberlain, A.G.	Master, F.G.; Master
Fisher, E.G.	Master, F.G.; 1st Officer
Newton, B.L.	Master, F.G.; 2nd Officer
*Christie, J.N.	Radio Certificate; W/O
Palmer S.	Supply Officer
Olcen, P.	Engineer 1st Class Motor, Chief Engineer
Gibson, R.B.	Engineer 3rd Class Motor, Senior Second Engineer
Flynn, J.	Engineer 3rd Class Motor, Second Engineer
Haines, T.	Engineer 4th Class Motor, Third Engineer
Stanway, D.	Engineer 4th Class Motor, Fourth Engineer

CSS *VECTOR*

Sjoholm, K.	Master, F.G.; Master
Price, G.	Master, H.T.; 1st Officer
MacKenzie, R.	Mate, H.T.; 2nd Officer
Vacant	Chief Engineer
Pearson, R.	Engineer 3rd Class Motor, Second Engineer
Conway, A.	Engineer 4th Class Combined,; 3rd Engineer.

CSS *RICHARDSON*

Wheeler, M.G.	Master, H.T.; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

MV *RADIUM EXPRESS*

Wiebe, I.	Master
Boudreau, N.	Chief Engineer

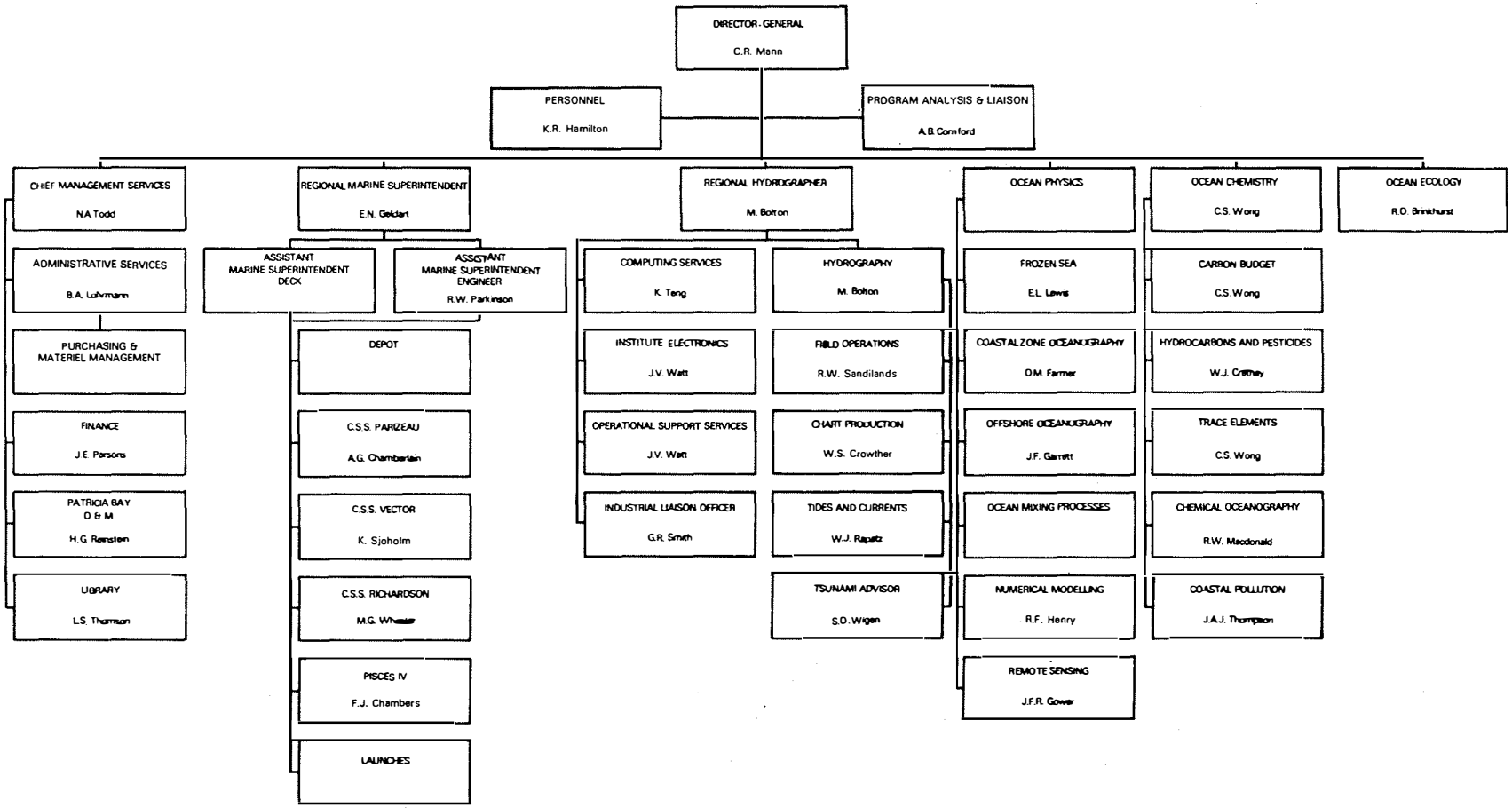
MV *PANDORA II* (Charter)

Jones, R.	Master
Newton, J.	Chief Engineer

PISCES IV

*Sanderson, I.	Chief Pilot
Chambers, F.J.	Chief Pilot
Taylor, R.H.	Pilot
Evans, D.	Pilot
Witcombe, A.	Pilot

*Left during 1979



December 1979