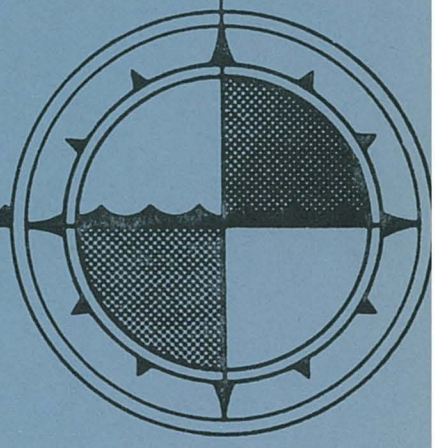
INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

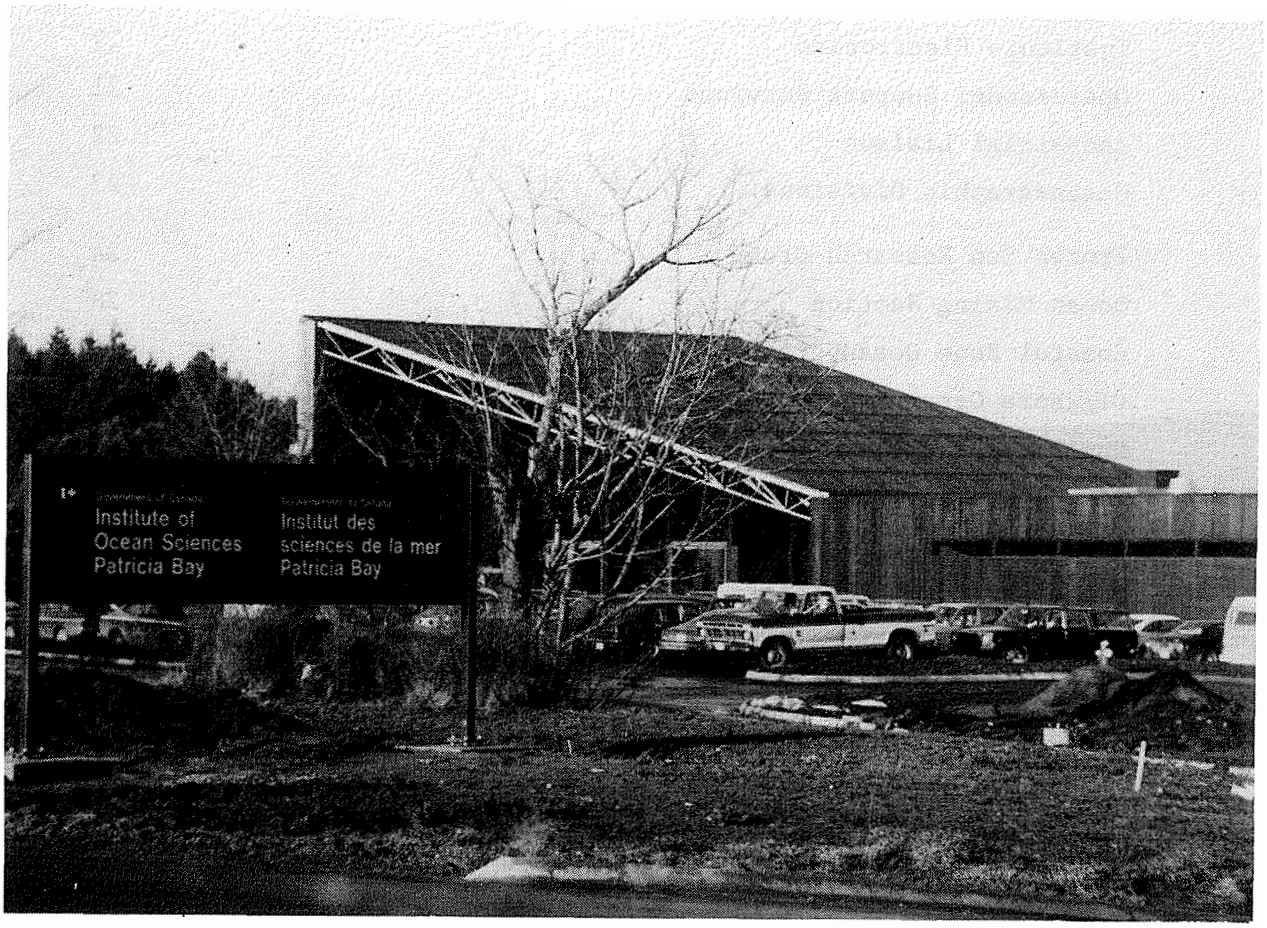
ANNUAL REPORT - 1977



INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Sidney, B.C.

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT 1977



Sidney, B.C.

March, 1978

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DIRECTOR-GENERAL'S OFFICE

R.W. Stewart

T. Van Dusen A.B. Cornford

The year 1977 will almost certainly go down in the annals of the Institute of Ocean Sciences, and remain in the memories of many of those of us who make up the Institute, as the year of our new building. Although the Depot building was finished in 1976, and most of Ocean Physics had been working at Patricia Bay for some time, it was in 1977 that the move was really effected. In May, as planned, the major part of the Quadrangle building was occupied. We were brave (perhaps foolhardy) enough to schedule a major international meeting -- the Executive of the Scientific Committee on Oceanic Research -- for the week we took the building over. Perhaps surprisingly, both the move and the meeting went quite smoothly.

In September the Hydrographic Division and Management Services Division moved out from the top floor of 1230 Government Street which had housed them for so long. Those of us who worked downtown will miss Bastion Square, the pleasant choice of little restaurants and boutiques and the possibility of noonhour and afterhour shopping in downtown department stores. However we have the compensation of our fine new quarters with their resort hotel setting, of ready access to our ships, to aircraft and to the ferries and even more of the ready access to our colleagues. It is certainly easy to find some nostalgia for the former arrangements, but on balance it seems that few people regret the change.

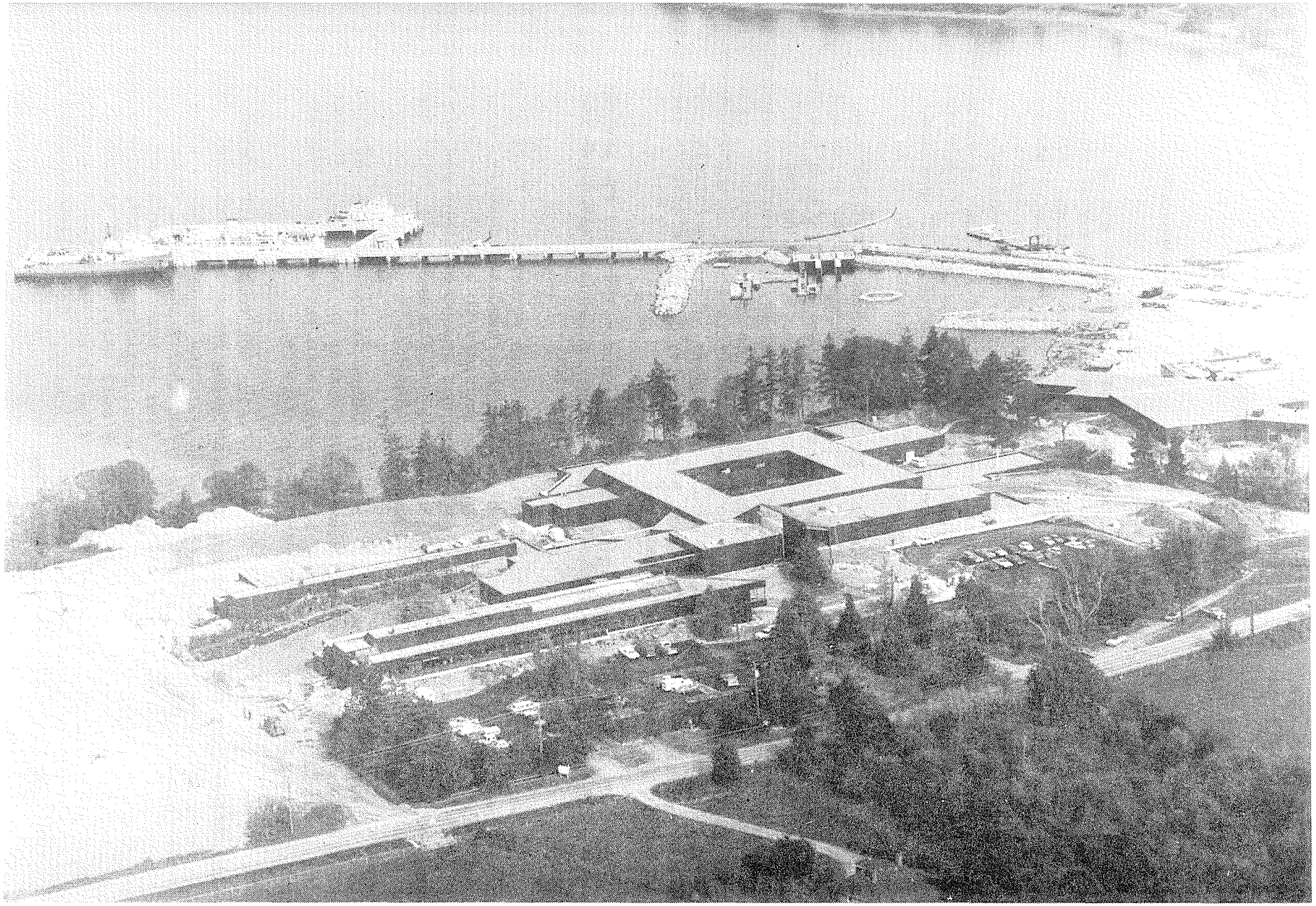
With the move of Ocean Chemistry in January 1978 and the arrival of the contingent from the Department of Energy, Mines and Resources in February all of the planned units will be in place.

We have ourselves a remarkable and unique structure. Those of us who have seen other Federal Government buildings around the country, a large proportion of which seem to have been designed to be defended in case of riot or insurrection, can only rejoice at the amount of light and air we have, the number of mature trees in our view, and the generally rural aspect which we can expect when the landscaping is complete.

Already the numbers of touring visitors is having some negative impact on our work. We can only expect this number to increase. However as we become accustomed to these visitors and learn better how to handle them, the interference with our work should dwindle.

Fortunately the trauma of moving seems not to have interfered to the degree that many had feared with our going about our business. In many cases the interruption in work hardly amounted to more than a day or so. In most it was a matter of a week or so. Our charts continued to be produced and to be sold. Our surveys got done -- even the Arctic ones this year where the *Pandora II* proved to be a substantially more effective vessel than many had expected. Tides and currents were measured and analysed, oceanographic and environmental impact work continued unabated in coastal waters, in the northeast Pacific and in the Arctic. The following pages will identify highlights of these accomplishments.

R.W. Stewart



Aerial view of the Institute of Ocean Sciences, Patricia Bay, October 1977

HYDROGRAPHIC DIVISION

REGIONAL HYDROGRAPHER

M. Bolton - Regional Hydrographer

D. Van Aanhout

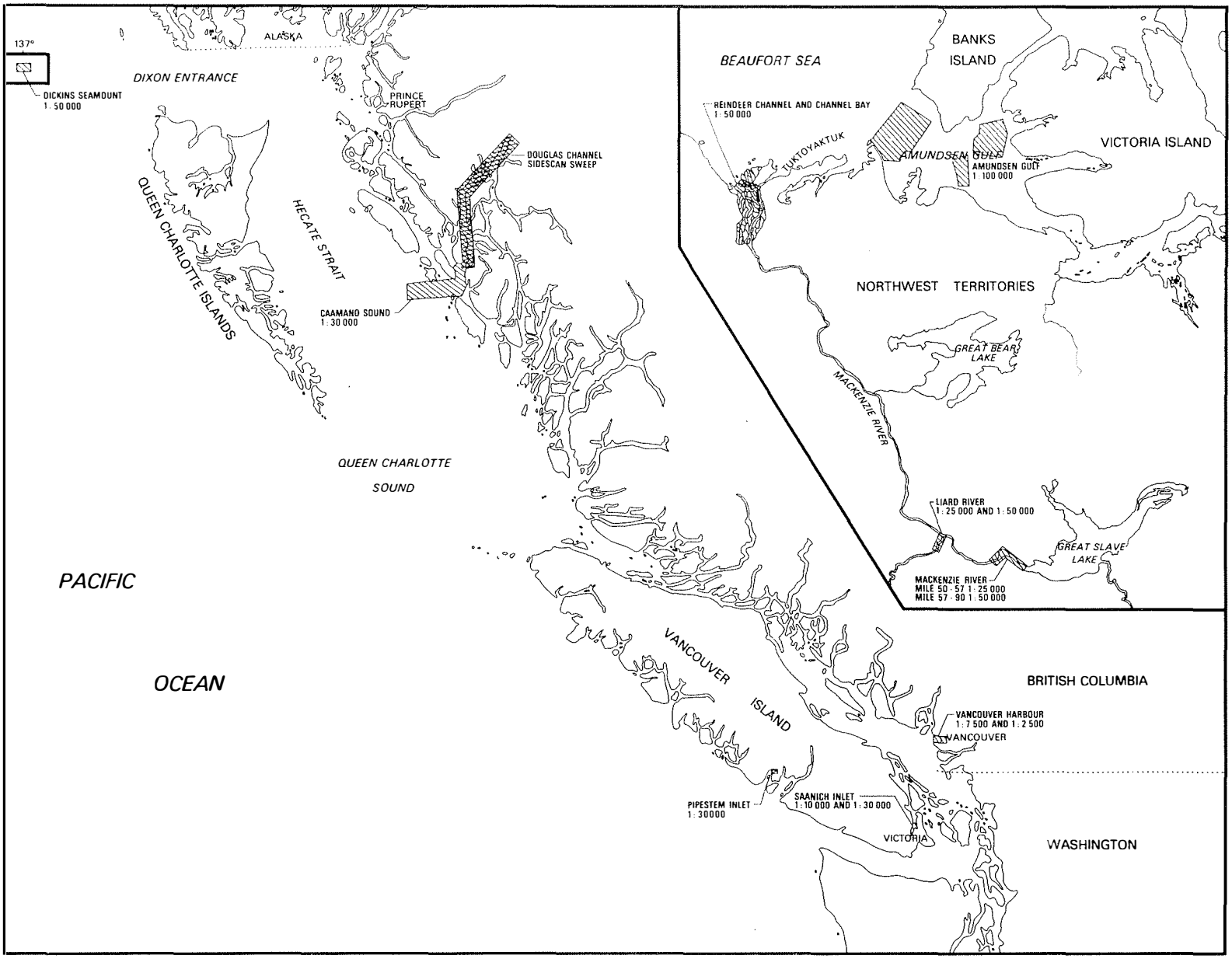
In early September the long anticipated move to new facilities at the Institute of Ocean Sciences at Patricia Bay occurred. The new location, about 30 km north of downtown Victoria, brings together all the Hydrographic Sections, and all of the essential support facilities in one modern complex, immediately adjacent to our ships and wharf. Aside from the obvious advantages of close proximity to all ship and support services the housing of oceanographers and hydrographers under a single roof will ensure closer program and scientific cooperation and coordination.

Investigations of real and potential tanker traffic routes demanded considerable effort from both Field Hydrography and Tidal and Current Surveys. Not only were field programs undertaken in Queen Charlotte and Caamano Sounds but additionally, considerable input was provided towards evaluation of the TERMPOL submission for Kitimat and towards the West Coast Oil Port Risk Analysis Study.

In 1977 a successful field program, involving the Department of Energy, Mines and Resources and Ocean Chemistry as well as Field Hydrography , was completed in the Western Arctic from the charter vessel *Pandora II*. Good ice and weather conditions were major contributing factors.

The acquisition and installation of a flatbed plotting system in the Institute has begun to greatly facilitate our chart construction activities. Plans for the purchase of a complete digitizing system are well underway and with the acquisition and installation of this equipment the first stages of transition to automated cartography are approaching their reality.

During the year extensive resources of both manpower and equipment were devoted to calibration of the new Canadian West Coast Loran-C Chain.



Field survey operations 1977

FIELD HYDROGRAPHY SECTION

R. Wills - Regional Field Superintendent

F.A. Coldham
J.V. Crowley
K.L. Czotter
G.H. Eaton
B.M. Lusk
A.B. Manley
R.I.D. May
P.R. Milner
A.R. Mortimer
A.D. O'Connor
R.D. Popejoy
M.L. Preece
*L.E. Prussner
A.R. Raymond
G.E. Richardson
+E.D. Sargent
R.U. Schoenrank
C.R. Tamasi
J. Vosburgh
+M.M. Ward
*J.G. Wanamaker
D.J. Wood
M.V. Woods

* Left during 1977
\+ Joined during 1977

R.W. Sandilands - Head Sailing Directions
J.W. Chivas
L.M. Wakefield

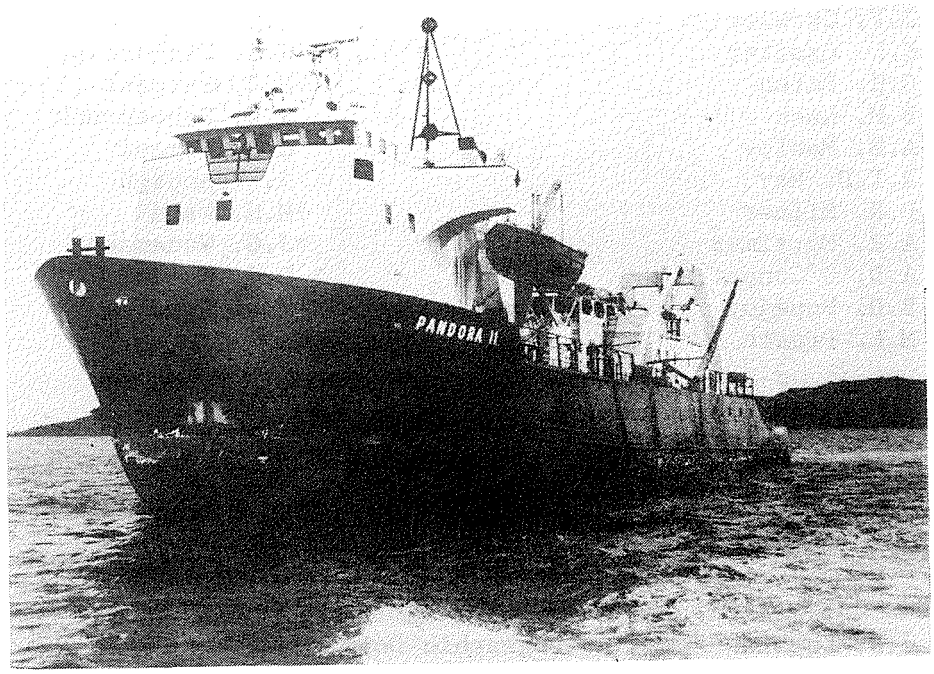
J.B. Larkin - Head Hydrographic Development
A.J. D'Aoust
**F.A. Coldham
**R.D. Popejoy

**Rotational Staff on Hydrographic Development

A major effort in 1977 was devoted to the calibration of the new Canadian West Coast Loran-C Chain. This entailed cruises on *Parizeau*, *Vector* and *Pandora II*, as well as truck and helicopter operations to the B.C. interior, Williams Lake and George, Washington. The data collected, and now being processed, is essential to ensure the proper construction of chart lattices and, in addition, will provide the material for at least five important reports. This was a cooperative project involving, in addition to regional resources, the Nautical Geodesy Division at Headquarters, Ottawa, the Navigation Group at the Atlantic Oceanographic Laboratory, Central Region, Canadian Hydrographic Service, the Canadian Coast Guard, the U.S. Coast Guard and the Pacific Centre of the National Ocean Survey at Seattle.

A major resurvey of Vancouver Harbour was undertaken and the main area between First and Second Narrows was completed. In view of the possible development of Kitimat as a supertanker port, a new survey of Caamano Sound was completed by C.S.S. *Parizeau*, and C.S.S. *Richardson* which carried out a side scan sonar sweep of most of the route to Kitimat, though

additional areas remain to be swept in 1978 if all possible routes are to be covered. The field sheets of the side scan sonar sweeps are unique for this region, showing extensive bottom characteristics as well as depth. Surveys of Pipestem Inlet and Effingham Inlet in Barkley Sound were completed as well as some final work to complete modern surveys of Saanich Inlet.



Pandora II at anchor in Amundsen Gulf in 1977

Pandora II had a successful season in the western Arctic conducting multi-disciplinary surveys in Amundsen Gulf, also completing a survey of Dickins Seamount and carrying out GEBCO (General Bathymetric Chart of the Oceans) sounding and Loran-C checks en route.

The contract for Revisory Surveys (Charts and Sailing Directions) was increased to cover most of the southern B.C. coastal waters, and was the only such operation carried out by the Region in 1977.

Annual surveys of the Athabasca-Mackenzie Waterway were continued by *Radium Express* with emphasis on the delta areas. Soundings were acquired on the Liard River at the confluence of the Mackenzie mainly in support of studies being conducted by the Glaciology Division of the Department of Energy Mines and Resources. Photographic surveillance of artificial islands in the Beaufort Sea was maintained with flights in early July and late September.

In preparation for next year's offshore surveys, geodetic positions were established on mountain tops on the west coast of the Queen Charlotte Islands, employing two satellite positioning systems.

Sailing Directions

The third edition of Small Craft Guide, Volume I was published early in the year. The limits of this publication were extended to include Port Alberni to Sooke and Nanaimo to Campbell River.

The second edition of Small Craft Guide, Volume II has been revised and expanded to give coastal coverage to Prideaux Haven. It is due from the printers early in 1978.

These two companion volumes now give small craft coverage for the southern waters where the majority of recreational boating takes place in British Columbia.

The seventh edition of B.C. Sailing Directions (North Portion) Volume II has been revised and is also due from the printers early in 1978.

Mr. Chivas joined C.S.S. *Parizeau* in March for a field inspection of portions of the northern coast including the west coast of Queen Charlotte Islands while the ship was on an oceanographic cruise. He returned with first-hand information for inclusion in sailing directions.

The section participated in a contract for Revisory Surveys and obtained information on new facilities and field sailing direction revisions in the Strait of Georgia and the inside coastal waters as far as Rivers Inlet.

Hydrographic Development

A. D'Aoust, who joined the development group late in 1976, moved to Victoria in November after being seconded to Canada Centre for Remote Sensing in Ottawa for one year to participate in the Aerial Hydrography Project.

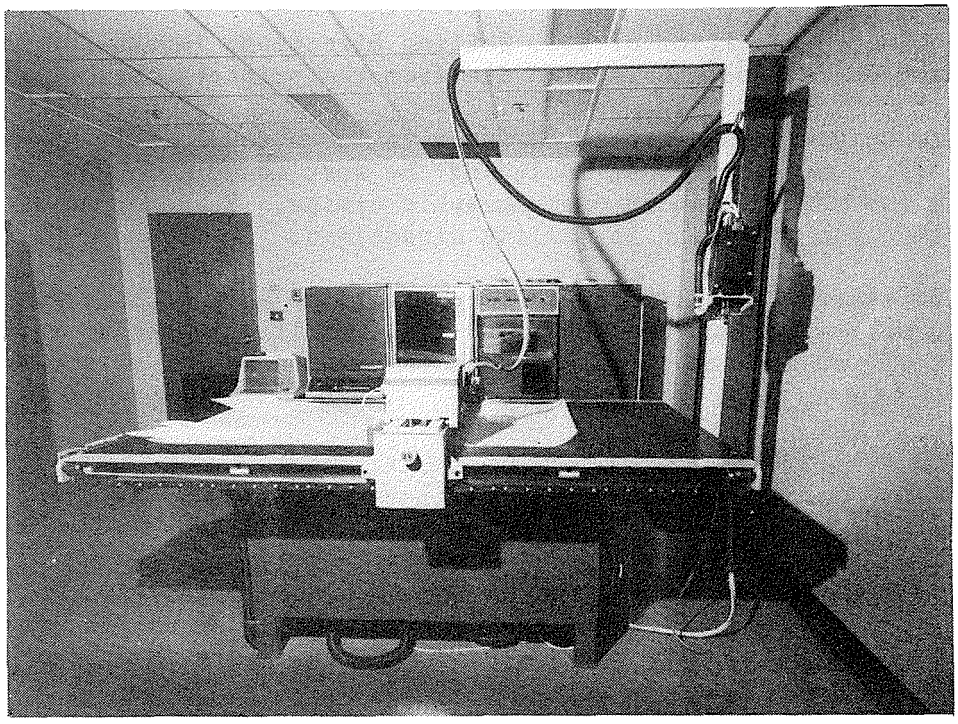
In the spring, flight tests were conducted over the Casa Grande Military Photo Test Range in Arizona. During the summer these data were analyzed, and preparations made for over water flight tests in Pacific Region in the fall. The development group conducted control surveys at three areas, then placed and maintained ground targets during the flights.

In preparation for the hydrographic field season, R. Tamasi, Field Hydrography and J. Galloway, Institute Electronics, held a successful operators' course on PHAS (Portable Hydrographic Acquisition System). The course ran for one week in a classroom environment, and included "hands on" experience with PHAS units coupled to depth and position simulators. D.B. Smith, Computing Services, adapted the FORTRAN HAAPS software to process PHAS data, introducing improvements at the same time.

Two new PHAS units were delivered late in the year and acceptance tests were carried out.

A summer student spent two months documenting older FOCAL programs, and implementing FORTRAN programs from the University of Victoria IBM to the Institute UNIVAC computer.

Installation of the Kongsberg flatbed plotting system, which was delivered in the spring, was delayed until late September, after the move to the new Institute. J. Larkin, as a member of the implementation committee, attended an operators' course at Bedford, Massachussetts, and participated in the installation and acceptance testing.



Kongsberg flatbed automated plotting machine

Programs necessary for plotting hydrographic field sheets from automated surveys were obtained from Central Region, and with the assistance of R.L.K. Tripe, Hydrographic Development, Central Region, were implemented on the Institute Computer. By yearend, the plotter was fully operational, and eight field sheets from Western Arctic, Caamano Sound, and Vancouver Harbour had been plotted.

J. Larkin attended the annual joint meeting of the American Congress on Surveying and Mapping, and the American Society of Photogrammetry in Washington, D.C.

CHART CONSTRUCTION SECTION

F.R. Smithers - Regional Chart Superintendent

R. Bell - Supervisor Chart Construction
*K. Bennett
P. Browning
G. Chan
D. Clark
*E. Coulter - Supervisor Chart Correction
W.S. Crowther - Production Chief
D. Dobson
E. Earl
M. Farmer
D. Fisher - Supervisor Chart Sales
M. Hohl
K. Holman - Supervisor Chart Revision
*R. Johnson
K. Josephson
R. Korhonen
D. Kynoch
A. Lyon
W. Lyons
P. Morton
*C. Nast
G. Neilson
R. Parker
M. Patton
A. Philp
L. Pickell
R. Pierce
A. Ross
N. Said
R. Taylor
M. Taylor
L. Thompson
B. Watt

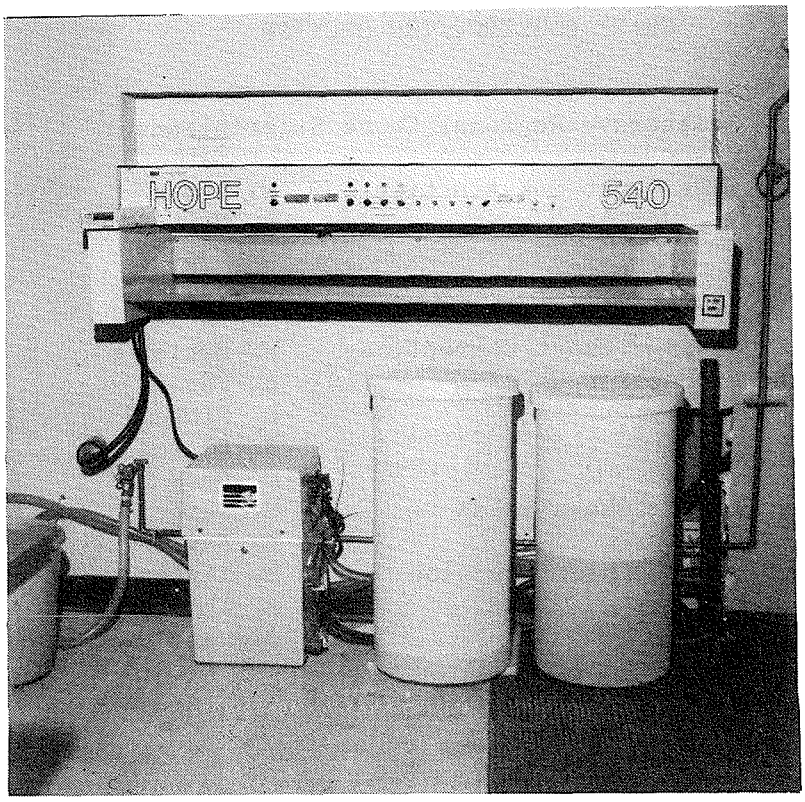
*Left in 1977

For the most part Chart Construction's move to their new quarters went smoothly and there was a minimum of disruption to the staff. Some problems were experienced, however, with the reorganization of the large chart inventory and re-establishing of the photographic services.

As a result of Headquarters decentralization and the heavy work load, the Chart Construction staff was increased by four over the past year. The new position of Pacific Region Production Chief is now filled. Two junior positions were also filled and one position was filled by a transfer from the Field Hydrography Section.

Two members of the Pacific Region Chart Construction staff completed the first Cartographic Training Course held in Ottawa this past spring. The course proved to be beneficial and further West Coast participation in future courses is anticipated.

The Chart Construction photographic laboratory received a Christie Automatic Film Processor this year and its installation coincided with the move to the Institute. This equipment aids in maintaining a high standard as well as greatly reducing the turn around time for Chart Construction's reprographic materials.



"Reprodot" automatic film processor

Chart Construction, in a joint venture with Field Hydrography, purchased a Kongsberg 1216 Flatbed Plotter and delayed the installation until the time of the move to the Institute. This equipment forms the base from which the Pacific Region Chart Construction Section will "get its feet wet", in automated Chart Construction. The Kongsberg system is capable of assisting in the production of reprographic material by inking, scribing, film cutting and photo-plotting. Four members of the Pacific Region staff have received training in the operation of the system and work is underway to make Headquarters development section's drawing routines compatible with the Kongsberg system.

In the past year emphasis has continued on the production of metric charts for the Juan de Fuca Strait and approaches to Vancouver Harbour. This region currently has seven charts under construction with an additional three to be started to complete this series. Two Loran-C small scale charts are in hand to provide coverage for deep draught vessel traffic off the west coast of Vancouver Island and an additional five charts complete the present work load.

The statistics for the past year give some indication of the work produced:

New Editions processed[a]	55
Reprints processed[a]	9
New Charts processed[a]	6
Notice to Mariners processed	64
Chart Corrections made	1,572,975
Charts Distributed	175,938
Chart Dealers Inspected	22
Chart Dealers established	13
Chart Dealers Withdrawn	4
MAREPS Processed[b]	426

a Includes compilation, draughting and printing.

b MAREPS - Marine Reporting Systems established in cooperation with Canadian Power Squadrons.

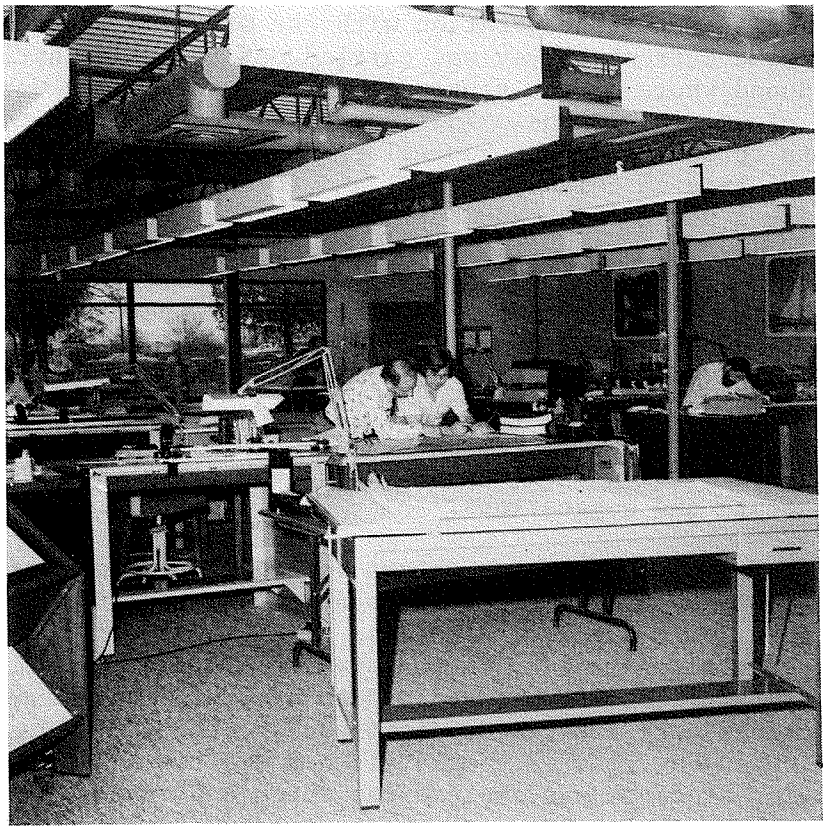


Chart Construction

TIDAL AND CURRENT SURVEY SECTION

W.J. Rapatz - Acting Regional Tidal Superintendent

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

* Left in 1977

The Tidal and Current Section conducted surveys on the British Columbia coast and in the western Arctic.

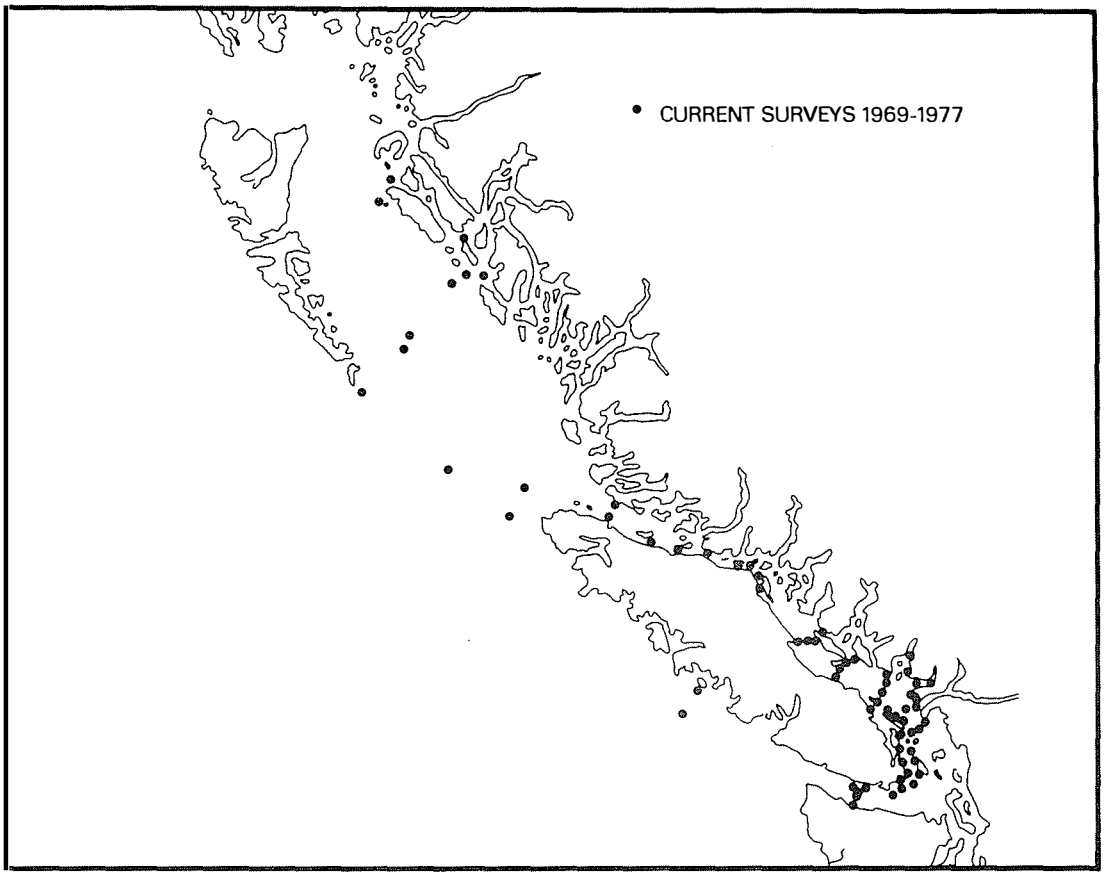
A major field program investigating the oceanography of Johnstone Strait was carried out in cooperation with the Offshore Oceanography Section. A major tidal and current survey was carried out in Queen Charlotte Sound and Caamano Sound where 3 tide gauges and 19 current meters were deployed for a period of several months. This survey was carried out to collect necessary data to advise on the route large tankers would follow on approaching the British Columbia coast, and to assist mathematical modellers in constructing a model of Queen Charlotte Sound and Hecate Strait.

At the request of the Ministry of Transport, a current survey was carried out at the entrance to Eskimo Lakes in the western Arctic. The Ministry of Transport ship *Nahidik* was used for this purpose for a period of 6 days.

Preliminary pages of a proposed current atlas of Juan de Fuca Strait and the Gulf Islands were constructed and distributed to major users to elicit comments and suggestions.

Several temporary tide gauges were operated in support of hydrographic field parties. A gauging station was constructed at Kitimat in support of the oilport inquiry. Aanderaa tide gauges, which were deployed last year at several permanent gauging stations in the Arctic, were recovered, and the records processed. Records from 24 permanent and 6 temporary stations were processed, digitized and the data sent to Marine Environmental Data Service. A completely new digitizing system for these analogue gauging stations was implemented which has enabled us to reduce significantly the time required for processing and to improve the accuracy of tidal data.

A field survey of tidal currents, salinities and temperatures in the main arm of the Fraser River was intensified and extended to other parts of the delta. This project was undertaken by the hydraulic research



Locations of current surveys conducted by
Tidal and Current Survey Section from 1969 to 1977

unit to provide an existing numerical model with additional parameters and hence improve its predictions of vertical as well as horizontal tides. Observations were made jointly with Water Quality Branch of Inland Waters Directorate. Production runs of the numerical model of the Fraser were continued for government agencies and engineering firms.

The design of a previously developed oil-spill tracking device was modified and adapted for airborne surveillance. Using a variety of oil spill simulators, a number of drift experiments were carried out in the Strait of Juan de Fuca to examine the surface movement and the possible path of a future spill in that area. The hydraulic research unit also participated in the West Coast Oil Port Comparative Study, by compiling the available oceanographic data in B.C. waters and designing a variety of oil spill scenarios.

Analysis of approximately 80 time series of current measurements made by our section and by U.S. National Ocean Survey was carried out, using a newly developed method to find time and rate comparisons between sets of observations. Four secondary current stations were added to Vol. 5 of the Canadian Tide and Current tables.

The records retrieved in 1975 and 1976 from tide gauges on Union, Bowie and Surveyor Seamounts in the North Pacific were analyzed, and tidal charts of the eastern portions of the North Pacific were prepared. These are the first deep sea tidal records obtained off the west coast of Canada, and will aid oceanographic research within the 200 mile fishing limit. These charts are part of the Canadian contribution toward an international program to map the tides in the central basins of the oceans. Research was begun on the effect of atmospheric pressure changes upon sea levels and currents in the North Pacific by examining the long period signals observed in these records.

A spectral analysis program has been tested on short term tidal records (less than 1 year) to improve the resolution of the harmonic constituents. The response method of tidal analysis has been adapted to the Institute of Ocean Sciences computer, and is being used on the seamount records.

TSUNAMI ADVISOR

S.O. Wigen

S. Wigen returned December 1st, 1977 from a posting of more than 2 years with UNESCO as Associate Director of the International Tsunami Information Center in Honolulu. He worked there under Canadian funding, and was concerned with mitigating the effects of tsunamis throughout the Pacific. He visited Indonesia and Australia after the destructive tsunami of August 19th.

Mr. Wigen is presently on a special assignment coordinating a historical study of tsunamis to provide a better data base for tsunami research and warning systems.

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns	P.J. Richards - Nuermical Modelling
D.B. Smith	+M.E. Woodward - F.S.R.G.
J.W. Butcher	A.L. Woollard - Tides and Currents
A.N. Douglas - Tides and Currents	*R. Dykes - Management Services
M.G. Foreman - Numerical Modelling	+S.J. Szalai - Management Services
J.S. Page - Ocean Chemistry	E. Wong - Offshore Oceanography

\+ Joined in 1977
* Left in 1977

1977 was a busy year for Computing Centre personnel involved in development of the Univac 1106 computer system at the Institute of Ocean Sciences. Conversion of all Ocean and Aquatic Science users from outside services (University of British Columbia (UBC) and University of Victoria) was essentially completed by the end of March. Dr. Crean's numerical model of Georgia Strait is now the only large application using an external computer.

Several additions and enhancements to the software available on the Univac system include a new level of the Operating System featuring remote console support enabling a user to make direct enquiries to the system, new versions of language compilers, new versions of the Editor, Sort/Merge and implementation of the NYU news processor to provide timely information to users, and implementation of additional applications software such as: Calcomp plotting routines with Tektronix preview capability (February), Univac Math/Stat package, UCLA BMD statistical programs, and selected routines from the UBC sub-routine library.

The system 2000 Database Management System was used in the implementation of several applications, including an Inventory Management System and library book catalogue for the Institute, a fish health inventory for the Pacific Biological Station, and a Fraser River Inventory and Herring Spawning information for Fisheries Management.

The Central Processing Unit (CPU) and memory were upgraded in April effectively doubling user memory and reducing swapping of programs, thereby improving response time and throughput. It also enabled implementation of a PL/I compiler and system performance measurement aids.

A Uniservo 16 magnetic tape sub-system was added, an EBCDIC - Field data hardware translator was included to facilitate the conversion of IBM (EBCDIC) tapes produced elsewhere, and 4 low speed communications ports were added, bringing the total to 10 for dialup access. A positive power-disconnect switch was installed in April to disable the system in event of a power interruption, since serious power problems in January resulted in some hardware damage with consequent down-time.

In April, operator hours were extended to 12 hours (0800-2000 hrs) and the system was left on (in unattended mode) during week-day evenings to enable access for time-sharing users. Preventive maintenance time was gradually reduced, being replaced at year's end by running on-line diagnostic routines. The average system availability during scheduled hours despite power problems and interruptions was about 90% and by December 71% of batch jobs were turned-around in 10 minutes or less. A Computing Centre Information Service (telephone 656-8333) was established in June manned by Computing Services staff on a rotation basis to answer questions about use of the system and to provide some debugging guidance.

The charging algorithm was established and charge-back to users was implemented, effective 18 April 1977. The first month-end reports were distributed in July and the first accounting statements and invoices for non-OAS users were available in October. The rate structure was designed to be competitive with external service bureaus. The latest set of benchmark comparisons indicated that the average cost of runs performed on the Univac was approximately 75% of the University of British Columbia commercial rates.

The average monthly usage (from April) during 1977 was:

OAS users	$18,853
Other users	5,054
Total (all users)	$23,907

This approximately equals the monthly operating cost of the Univac 1106.

Computing Services personnel have been directly and indirectly involved in numerous projects with the other groups now on site at the Institute. The use of PHAS data acquisition systems by Hydrography required the development of interface routines for Hewlett-Packard and PDP-8 computers as well as a PDP-8 Fortran IV package for in-field processing of survey data. This package is based on the old HAAPS processing system with added features for dealing with large-scale surveys such as Vancouver Harbour. The Sykes 9250 floppy disk (acquired in March) proved its worth in this development effort. Local plotting of Hydrographic field sheets on the new Kongsberg flatbed plotter is now possible, using plot tapes generated on the UNIVAC system with programs adapted from Central Region.

Various new devices were interfaced to the minicomputers. Arctic Marine Science has connected a Guildline Digital CTD recorder to the Hewlett-Packard 2116 disk operating system. Tides and Currents implemented a similar link from their HP-9825 calculator-based digitizer to the HP 2100. Coastal Zone applied a multiple digital-to-analog converter (MULTIDAC) interface, designed by Institute Electronics, to produce graphic output on an X-Y recorder. Data logging capability for the Current Shear Probe was provided by extending Offshore Oceanography's CTD acquisition system. A transcription program for Offshore's Geodyne current meter data cartridges was started late in the year, with an interface designed by Institute Electronics.

The micro-computer is also here to stay. Software development is in progress for a micro-processor based data logger being built jointly by the Ocean Mixing and Institute Electronics Sections.

INSTITUTE ELECTRONICS

J.V. Watt - Head

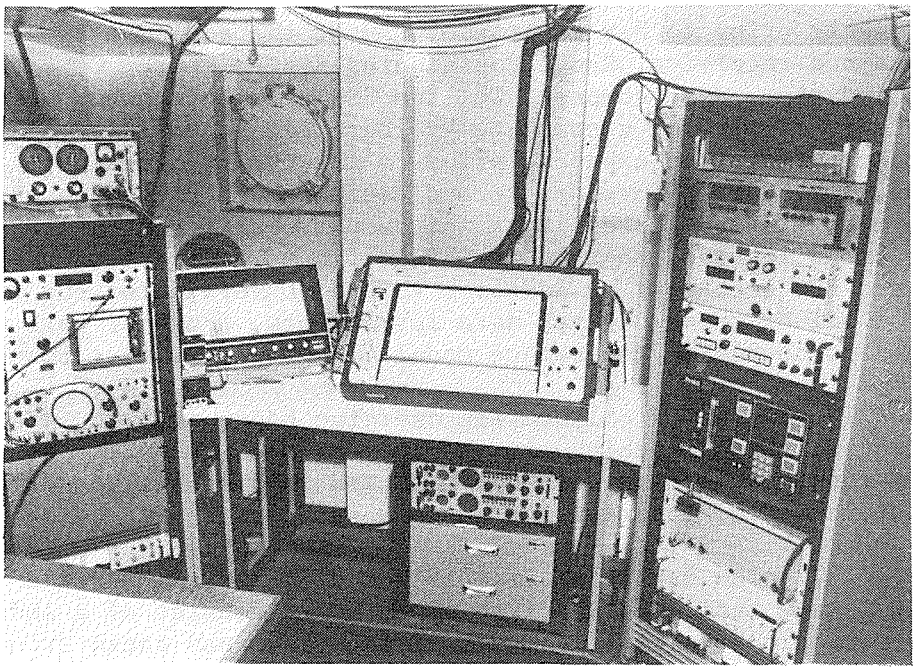
R.A. Cooke - (with FSRG)
T.A. Curran - Project Engineer
L.W. Dorosh
J.L. Galloway - Project Engineer
D.G. Gregson
E.W. Hinds
*B.A. Johnson
R. Loschiavo
R.A. Muse
M. Osborne
**C.F. Ryan
T.J. Soutar
W.R. Taylor - Head, Technical Support Group

* joined during 1977
** left during 1977

The major event of 1977 involving the section was the move to the new institute facilities which are already proving their worth in easing the complications involved in the provision of electronics support. Following this move, in keeping with expanding role of the section, Survey Electronics was renamed Institute Electronics. The section continues to provide electronics engineering and technical support to the Institute of Ocean Sciences.

Engineering Support

The engineering staff were very active during 1977 providing continued support of the Portable Hydrographic Acquisition System (PHAS), development of specifications and an implementation plan for a flatbed draughting system to address Institute-wide needs and completion of a number of oceanographic instrumentation projects.



Data acquisition station. PHAS (center at right)

Courses prepared and presented in support of the PHAS included an operations course for hydrographers and a maintenance course for service technologists, the latter being attended by personnel from Central and Eastern regions. Further activities involving PHAS included software modifications which permitted the recording of magnetometer data in conjunction with hydrographic information and the revision of specifications for a contract which was let for the manufacture of three new units (one for Energy Mines and Resources, Geological Survey).

Continued engineering support to assist the oceanographic sector involved the completion of a computer compatible interface for a Gould, six-channel chart recorder and of a local contract for the construction of a number of Aanderaa data tape readers. Major projects undertaken during 1977 included the development and field testing of a current shear probe system which utilized an ultra-sonic current meter head, the start of the development of a high speed, high resolution microcomputer controlled 64 channel data acquisition system for the submersible *Pisces IV* and a plug-in depth digitizer for the PHAS.

Technical Support

The Technical Support Group provided field support for the Caamano Sound, Vancouver Harbour, MacKenzie River and the Amundsen Gulf surveys. The Arctic program was greatly assisted by on site modifications to the PHAS software. In preparation for this 1977 Arctic cruise a major equipment installation was successfully carried out on *Pandora II* during the two weeks prior to her departure. Among the equipment installed were Decca, Lambda receivers, Range Positioning System, Loran C, satellite navigator system, gyro compass, Collins SSB radiotelephone, inter-com, facsimile receiver, and a complete hydrographic acquisition station. Significant effort was expended prior to the 1977 field season to make all sounders, depth digitizers, pattern digitizers and microwave positioning systems compatible with the input and output requirements of PHAS. These modifications included PHAS controllable fix mark circuits on the Ross, Atlas, and EPC recorders in addition to the conversion of the output format of all of these digital data instruments. Further work was performed to couple an Innerspace model 412 digitizer to a Ross Sounder.

The Loran "C" calibration exercise begun in 1976, was ably supported and involved shipboard, helicopter and mobile lab equipment installations, cruises on both *Parizeau* and *Vector*, helicopter flights and trips into the B.C. interior and north-west U.S.A.

1977 also marked the initiation of a program for the installation of an Institute radio base station which shall consist of a 1KW transmitter and log periodic beam antenna covering the frequency range from 6 to 30 MHZ and a locally controlled receiving and low powered transmitting station.

OPERATIONAL SUPPORT SERVICES

J.V. Watt - Head

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

*** Transferred from F.S.R.G.

To accomodate a growing need for mechanical design, construction and testing services in the region, two shops, one for mechanical design and another for fabrication and mechanical testing, were incorporated in the design of the Institute. The responsibility for these facilities was assigned to a new section, Operational Support Services.

Mechanical Support

The mechanical support section started during 1977. The section provides mechanical design, instrument making, machining and fabrication services in addition to facilities management. The section also is to provide mechanical expertise in preparing specifications and initiating and supervising contracts let to local industry related to this area of endeavour.

The mechanical design shop is equipped as a precision machine and instrument making shop and shall, by early 1978, have a mechanical drawing office. The major equipment available includes two precision lathes, one mill and a variety of drill presses, grinders and saws.

The fabrication and mechanical test shop is equipped with welding, sheetmetal, woodworking and grinding facilities as well as a cleaning tank, bead blast and a paint booth.

INDUSTRIAL LIAISON

G.R. Smith - Industrial Liaison Officer

The level of expenditure on science related contracts has increased steadily each year since the introduction of the Make-or-Buy policy, and continued to do so in 1977/78. The Institute is now spending greater than 50 percent of the operations and maintenance budget available for oceanography in support of contracting.

This total is unlikely to increase unless there are increases in overall funding. As a result, other government sources of funding such as unsolicited proposals are becoming increasingly important as a means of stimulating contract activity and much of the increase in 1977/78 was due to these funds. Until economic restraints are lifted, a major objective is to maintain the present level of contracting and, where possible, find other sources of funding.

It is probably too early to identify results of contracting policy, but a few significant things have happened during 1977/78. Several companies have decreased their dependence on government contracts and are obtaining a greater number of industrial contracts. This is at least partially due to improved capability and experience derived from government contracts. Also the commercial market for science related activities appears to be expanding as a result of an increased awareness of the importance of oceanography in both environmental and engineering studies. We hope this is the start of a continuing trend.

OCEANOGRAPHIC DIVISIONS

P.W. Nasmyth - Regional Oceanographer

S. McKenzie

As part of an internal reorganization following the retirement of the former Deputy Director-General, and discontinuation of his position, the position of Regional Oceanographer was created to provide central focus and management for the oceanographic research programmes in Chemistry, Physics and Biology and to encourage inter-sectional and interdisciplinary cooperation. Consolidation of all components of Ocean & Aquatic Sciences, Pacific Region in the new Institute building at Patricia Bay brings the various groups into closer contact with each other and should further stimulate the exchange of ideas and facilitate the development of a coherent and efficient programme.

Continued erosion of available resources by almost universal cost increases, X-Budget cuts and inevitable expenses involved in relocating into the new building, has demanded very careful planning and a very lean programme in 1977. It has, however, been an active and productive year, with a number of programmes (particularly in the Arctic) assisted by infusions of funds and logistic support from outside agencies including the Environmental Protection Service and Atmospheric Environment Service of the Department of Fisheries and the Environment, the Department of Indian and Northern Affairs and several commercial organizations. In spite of financial pressures it has been possible to supplement our internal programme and maintain our Make-or-Buy support of research and development in Canadian industry at about the same level as in 1976. If present trends continue, however, increases in costs will almost certainly lead to a reduction of funds available for contracting in the oceanographic programmes in 1978.

Oceanographic work in support of environmental impact assessments has taken an even larger proportion of the total programmed effort than in the past few years, with the Canadian Arctic Archipelago and the northern coastal waters of British Columbia receiving priority attention. Preparation for Canadian oceanographic participation in the First GARP Global Experiment, with successful trials of the Institute of Ocean Sciences/Hermes drifting buoy, has been a prominent Canadian feature in the international scene, as active involvement in the experiment approaches in mid-1978.

The infrastructure of the oceanographic programme remains as in past years. Detailed reports from each section follow.

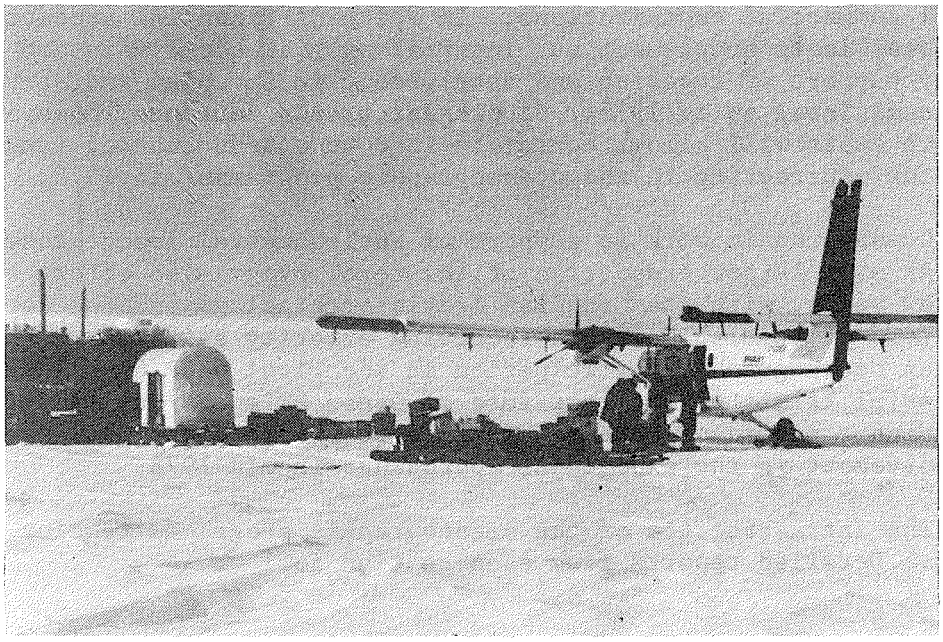
FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

*J.W. Butcher - Computing Services
R.A. Cooke - Institute Electronics
A.W. Koppel
R.A. Lake
J.M. McNeill
*A.E. Moody
S.W. Moorhouse
R.G. Perkin
D.L. Richards
*E.E. Richards
R.B. Sudar
D.R. Topham
E.R. Walker
+M.E. Woodward - Computing Services
P.E. Greisman - Postdoctoral Fellow

+ Joined in 1977
* Left in 1977

The Frozen Sea Research Group was established in 1964 to study oceanographic problems unique to ice covered waters and their research efforts have been concentrated in the Canadian Arctic. Much of their expertise in the scientific understanding of oceanographic processes in Arctic waters is now being directly applied to the problems associated with the exploration and exploitation of resources in the far north. The projects undertaken in 1977 are summarized below.



Assembling equipment on the sea ice prior to deploying current meters in Crozier Strait, April 1977

Water Movement in Channels of the Arctic Archipelago

In March 1977 an effort was made to retrieve ten current meters laid in 1976 across the bottom of Byam and Austin Channels between Melville and Bathurst Islands at about 75° north. It was a frustrating trip, as ice had carried away nine of the meters! It was indeed fortunate that the greater part of two months data had been obtained from the meters from our acoustic/radio telemetering and recording system before their destruction. After recovering one meter the tracked vehicle party crossed Bathurst Island via Polar Bear Pass to lay an array of 21 current meters across Crozier Strait between Bathurst and Cornwallis Islands. Meters were placed in the top and bottom boundary layers to obtain information on likely oil movement just under the ice, and about forces acting upon a bottom-laid pipeline. Meters were also positioned at mid-depth to allow calculations of water transport. The movement of pollutants from a hypothetical oil well blowout in the Arctic Islands is largely unknown and our studies are an essential part of predicting consequences of such an event.

Most of these current meters were removed in June and August but two bottom meters were left down to record through the winter with recovery planned for March, 1978.

Water structure (CTD and current profiles) was measured in Austin, Crozier and Pullen Channels.

Recovery of current meter from the sea floor in Austin Channel, March 1977. The meter recorded data for one year.

Fjord Studies

These continuing studies were centered at d'Iberville Fiord on Ellesmere Island during March and April when air temperatures lingered near -45°C (-50°F) for days on end. A salinity/temperature survey of the fjord was undertaken together with a survey of several micro-constituents (silicate, phosphate, nitrate) and dissolved oxygen, deuterium and tritium. The results showed that horizontal gradients of the passive tracers were undetectable while tritium reached high values near the tide water glacier. High tritium values result from the nuclear bomb tests in the 1960's.

Since ice cover prevents wind-mixing, and run off from the land is restricted to a few months of every year, Arctic fjords are a simpler circulatory system than fjords at more temperate latitudes. Results from studies on Arctic fjords may thus be used to elucidate problems arising from coastal pollution in southern Canada, for example on the British Columbia coast.

As the sea ice grows, salt is rejected into the underlying water column producing vertical convective motion immediately below the growing interface. The dynamics of this process are of great interest in regard to the lodgement and dispersal of oil deposited at the ice/water interface by an offshore oil well blowout as well as in terms of the fundamental physics of the atmosphere/ocean energy exchange and its effect on world climate. Attempts were made to employ ultrasonic current meters interfaced with a Hewlett-Packard 9825 A desk computer to measure the small scale convective flow patterns beneath growing sea ice. The convective surface layer beneath the ice was abnormally thin in March 1977 in d'Iberville Fiord, being less than 30 cm thick. Since this thickness was roughly the same as the dimensions of the instrument head, i.e. their spatial resolution, the correlation measurements were not useful. Early analysis of the records revealed a heavy incidence of turbulence attributed to seals attracted to the open warmed hole in the six foot thick ice through which our instruments were lowered.

Analysis of data taken in Cambridge Bay in previous years was completed. These illustrated the effects of internal waves breaking on the shore on the mixing of basin waters in this small fjord - a study of direct importance to the vertical movement of pollutants in arctic coastal waters.

A brief review of results from our fjord studies was included in a report on aspects of oceanography in the archipelago published during the year.

Deep Oil Well Blowouts

Release of natural gas (methane) invariably accompanies oil escaping in a seafloor oil well blowout. At sufficiently high temperatures this escaping gas can form a hydrate of density about 0.9 gm cm^{-3}. Previous studies had considered gas driven plumes from shallow depths but formation of hydrates in deeper blowouts would completely change plume dynamics and hence movement of oil escaping. Since the kinetics of hydrate formation are poorly known and the matter is of such importance, a program to elucidate

formation of hydrates was begun by releasing gas and oil from the submersible *Pisces* at depths to 640 m. Hydrates were observed to form in profusion. Therefore contracts were let for laboratory work in which kinetics of hydrate formation are being investigated in a pressurized vertical water tunnel in which droplets of oil and gas can be suspended.

A preliminary analysis of the release of gas from a saturated oil drop originating in a blowout in its buoyant passage to the sea surface indicated that it would probably become supersaturated as the pressure reduced. Spontaneous formation of gas bubbles within the drop is thus possible which could provide energy for emulsification. This fact combined with hydrate formation would change the clean up problem entirely.

Completion of the analysis of data collected during our simulated "blowout" in Patricia Bay in 1976 using compressed air showed that large bubble plumes are not equivalent to similar rising plumes produced by heating as had been thought previously.

Instrumentation

Considerable effort has been expended over the last few years to build a sensor chain which through simultaneous measurements of temperature and electrical conductivity will yield values of water salinity. First field tests this year indicated good long-term stability of our system and we are pushing ahead with the construction of a chain and tests of long-term deployment in a fouling environment. In the meantime, preliminary plans are being made for the commercial manufacture of this important instrument.

Because the north magnetic pole is situated in the centre of the area in which we are working in the Arctic the horizontal component of the earth's magnetic field is insufficient to give adequate directional indication to our current meters. By contract we hope to acquire current meters which will allow direction determination by acoustic orientation of the meter to an acoustic source in known position. This development promises the first practical attainment of current directions near the north magnetic pole for non-rigid moorings.

Salinity

The proposal for a "Practical Salinity Scale" based upon the conductivity ratio of the sample with standard seawater at 15°C has been accepted by the UNESCO/SCOR/IAPSO/ICES "Joint panel on oceanographic tables and standards" and will be submitted to its parent bodies for ratification. Standard seawater will be defined in terms of its conductivity ratio with a KCl solution of fixed concentration by weight and the primary form of the relation $S = F(R_{15})$ will be determined from measurements made on weight diluted standard seawater. Thus all seawaters having the same R_{15} will have the same practical salinity, irrespective of ionic content. The newly proposed definition is in accord with, and is being promulgated with, a new equation of state for seawater proposed by others. Together these formulations should enable a far more precise comparison of data between institutions than has been possible in the past.

OCEAN MIXING SECTION

P.W. Nasmyth - Head

A.E. Gargett
A.R. Nowell - Postdoctoral Fellow
G.W. Chase
R.C. Teichrob

This was a year of retrenchment and catch-up in the Ocean Mixing program. The major effort was an extensive modification to the *Pisces*-borne data sensing and recording system, for improved performance and reliability, lower noise levels and reduced cross-talk between channels. A continuing low level of effort has been put into the further analysis of old (pre-*Pisces*) data and extensive work has been done on performance characteristics of and calibration techniques for the Siddon-Osborn "shear probe" now used on *Pisces* for the two cross components of turbulent velocity fluctuations.

The re-built system, including a new data acquisition sub-system built around two micro-processors and using dual digital cassette units, will be ready for trials in early 1978.

Dr. Gargett has been on sabbatical at Woods Hole for the year, primarily to complete analysis of data from the joint Woods Hole/University of British Columbia/Institute of Ocean Sciences cruise in the Atlantic in 1975.

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. Nof - Postdoctoral Fellow
D.G. Sieberg
L.A. Spearing
J.A. Stickland
D.J. Stucchi

* Joined in 1977

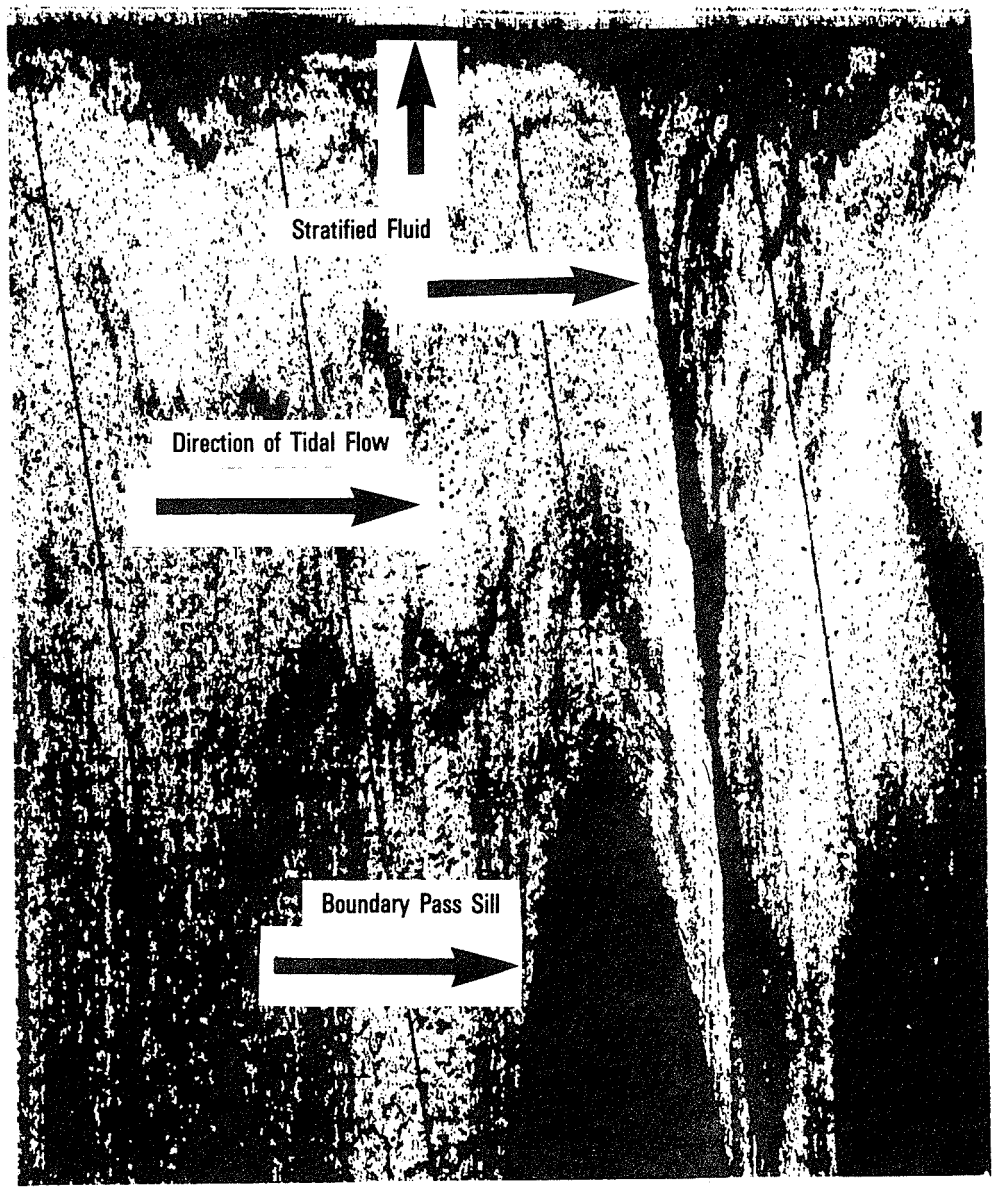
This year Coastal Zone continued and extended studies of physical processes in British Columbia Inlets. Our major program involved the study of Knight Inlet, with particular emphasis on the interaction of tidal flow with the sill and consequent effects on the circulation. This study has in turn provided new insights which have application to other areas, including the complexity of channels leading up to Kitimat. The Kitimat approaches are the focus of another study, undertaken by contract and motivated by concern over hazards associated with possible oil-port development.

Ongoing work includes the analysis of data collected in past projects (Rupert-Holberg, Haro Strait), development of mooring techniques, work on new instrumentation and software and projects relating to ocean dumping legislation. H.J. Freeland joined the group this year and concluded earlier work begun at the University of Rhode Island, connected with the Mid-Ocean Dynamics Experiment (MODE) program and also a study of the effect of variations in the earth's orbit on climate.

Knight Inlet Study

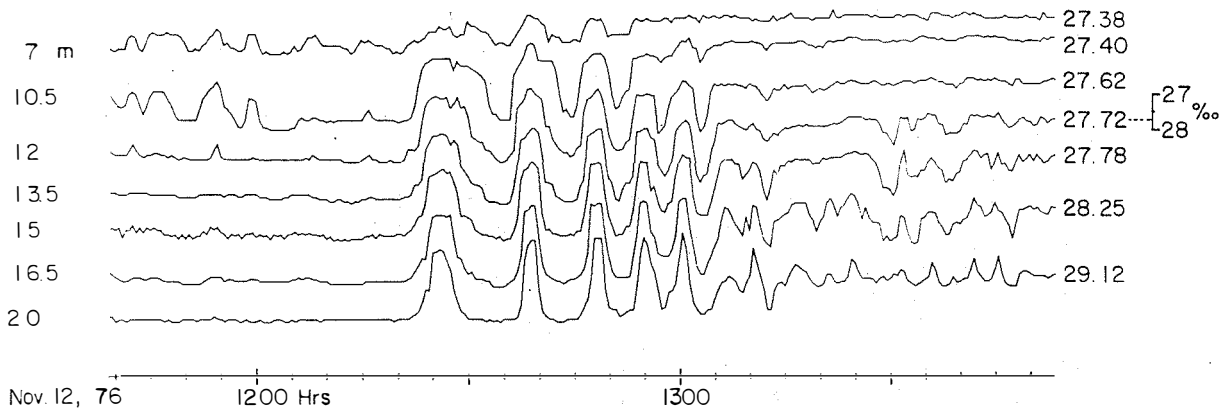
This year we began a study of the circulation of Knight Inlet. Observations included long term tide and wind measurements, a sequence of monthly temperature/salinity profiles and a detailed set of time series measurements of salinity, temperature and current velocity profiles conducted in August. For our August cruise we were joined by two ships from the University of Washington.

A remarkable result of the August cruise in Knight Inlet was the observation of an internal hydraulic transition over the shallow sill at the entrance to the inner basin. Tidally driven flow produced a critical condition over the crest of the sill which was followed by a hydraulic jump in the lee. These effects are visible on echo sounding records. The figure illustrates the dramatic plunge of surface water over the sill in Boundary Pass where similar phenomena have been observed.



Accoustic techniques are being used by Coastal Zone Section to help interpret the behavior of stratified flow over topographic features. In this example the surface stratified layer, which contains an accoustic reflector of unknown origin (possible biological matter or microstructure), is seen to plunge over the sill in Boundary Pass. The sill depth is approximately 60 m. Similar examples of internal hydraulic transitions are being studied in other areas of strong tidal forcing including Knight Inlet.

About one hour before slack water, the critical condition could no longer be sustained and the remnant of the hydraulic jump travelled downstream where it evolved into a travelling surge or undular bore. This appears to be the source of trains of internal waves which have long been observed in Knight Inlet and other inlets.



Time series plots of salinity at different depths during passage of a train of internal waves in Knight Inlet. Each plot is staggered to avoid overlap.

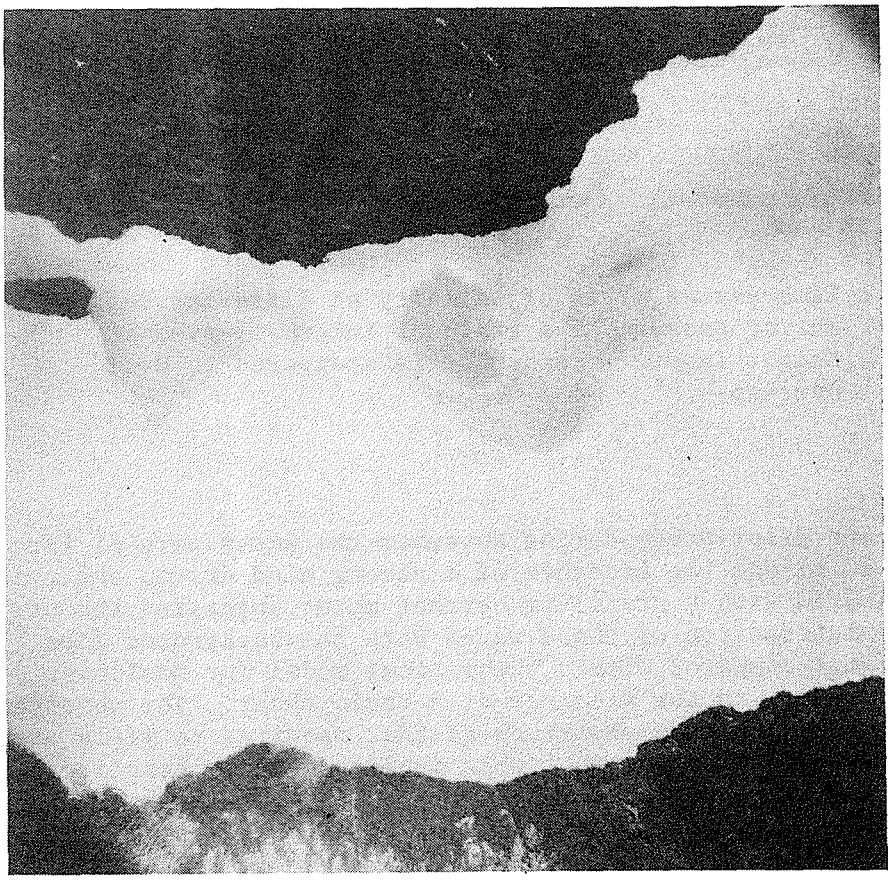
In our pilot study during November the waves were of large amplitude (> 10 m) and the presence of a strong wind driven shear zone which was measured with a profiling current meter suggested the utility of examining the interaction of these waves with the background flow. Observations were compared with a theoretical model for nonlinear internal waves in deep water, in the presence of a basic shear. The observed waves were approximately the same amplitude as that required to yield marginal dynamic stability, suggesting that this amplitude might constitute an upper limit; larger waves would quickly lose energy through shear flow instabilities.

Careful analysis of tidal records taken throughout the year have shown that small phase angle changes occur in the neighbourhood of the sill; moreover these phase changes may be interpreted by means of a simple model in terms of quasi-steady energy loss, and correlated with the stratification of the water. The energy loss is considerable and may have an important effect on mixing within the fjord. Estimates of the energy in the internal waves are consistent with the hypothesis that the waves constitute the main energy sink for the tides. This aspect is the focus of an additional experiment now in progress involving current measurements in the inlet.

The tide gauge data are also being used to observe small fluctuations in the sea-surface slope of the inlet. We hope to relate these changes to seasonal variations in the wind and river discharge.

Kitimat Study

An oceanographic study of the complex of channels leading up to the port of Kitimat has been undertaken. This project, which is motivated by the possibility of future oil port development, has been carried out by contract, with Coastal Zone staff providing guidance of both field work and data analysis. The project has two major thrusts; a comparison of observed and numerically modelled tidal flows and an analysis of gravitational circulation. The tidal heights and current measurements will be compared with a multi-channel one dimensional tidal model. Observed stratification is being interpreted in terms of a two-layer fjord circulation model adapted to the Kitimat channels.



Air photo of complex eddies in Knight Inlet. The eddies show up due to colour differences in the water, which depend on the concentration of suspended rock flour.

Rupert-Holberg Inlet Study

Analysis of 1975 data collected in the Rupert-Holberg system is leading to a more detailed understanding of the structure of the tidal jet. The observations allow limits to be placed on the horizontal spread of the jet, and vertical spreading is interpreted in terms of the density difference between inflowing and receiving waters and the amplitude of tidal excursion.

Saanich Inlet

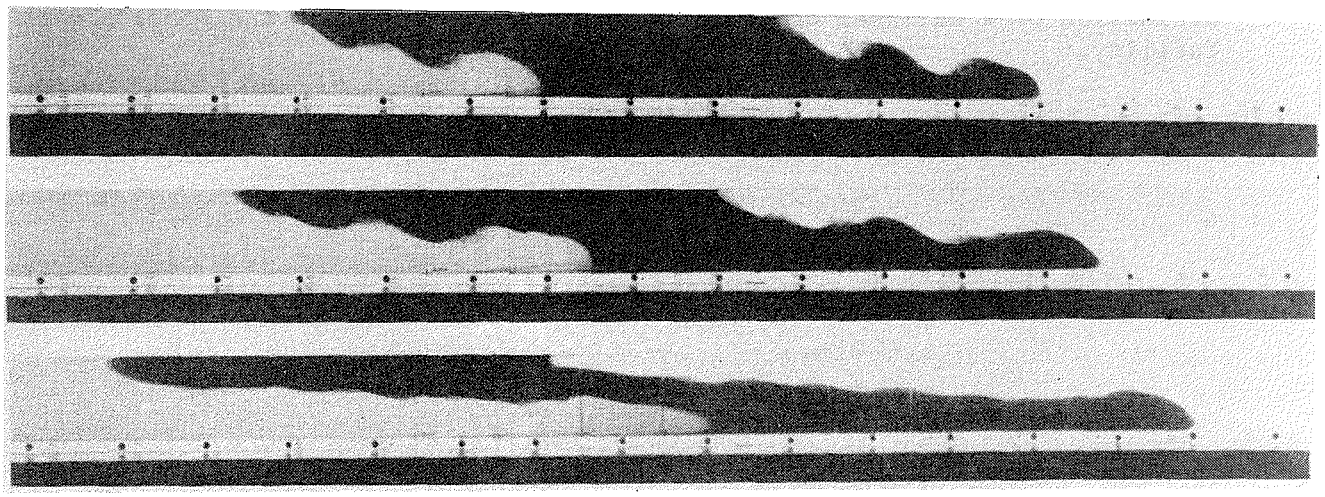
Observations of temperature, salinity and oxygen continue in Saanich Inlet as part of a long term examination of deep water exchange. This inlet which lies on the Institute's "doorstep" is a particularly convenient one to study; it is of interest in that it has a deep anoxic layer resulting from relatively poor exchange over the sill in Satellite Channel.

Lighthouse Program

While routine collection of salinity and temperature at B.C. Stations continued, two further studies of a more general nature were completed. The first of these concluded the statistical analysis and presentation of historical data from each of the stations. Another study, carried out under contract, examined the various options open for future lighthouse data collection.

Tidal Fronts - Haro Strait

Observations of tidal fronts in Haro Strait during 1975, provided the basis for a theoretical and laboratory study of the spread of mixed water in stratified surroundings together with the formation and movement of sharp density transitions. The laboratory model, which has three compartments with removable separators, the central compartment for the "mixed" water, yields a graphic display of the type of phenomena thought to occur in Haro Strait.



Mutual intrusion of fluids with various densities which leads to formation of a front. The liquid in the center (black) has an intermediate density, the one to the right (white is lighter and the one to the left (grey) is heavier. The photographs (taken at consecutive times) show the initial stages of intrusion.

Ocean Dumping

Studies of ocean dumping continued, with a further review of papers relating to dispersion of dumped material and a watching brief on developments in dumping technology. A contract was let for a study of the short-term oxygen budget of Alberni Inlet.

Mooring Techniques

Investigation of practical mooring problems relating to the flow drag of system components was continued. Drag coefficients for an extruded plastic cable fairing and for an Aanderaa thermistor chain were determined by using a mathematical mooring model in conjunction with data obtained from trial moorings. Other groups also used the model to assist them in mooring system design.

Instrument Development

Our August cruise in Knight Inlet gave us practical experience of the problems of current meter profiling. A contract was let to investigate the difficulties relating to the motion of a profiling instrument. This study emphasized the errors inherent in measuring such motion using accelerometers and gyroscopes. Further work on current-meter profiling is continuing in conjunction with Offshore Oceanography.

Task Forces

Contributions to environmental studies continued with input to a set of guidelines for the use of the B.C. coastal zone and its resources, and evaluation of a National Harbours Board proposal to expand the Roberts Bank facility.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett - Head

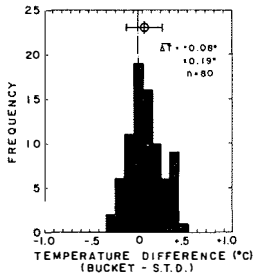
C. de Jong
P. Kimber
L. Kuwahara
J. Linguanti
J. Love
B.G. Minkley
M. Miyake
S. Tabata
R.E. Thomson

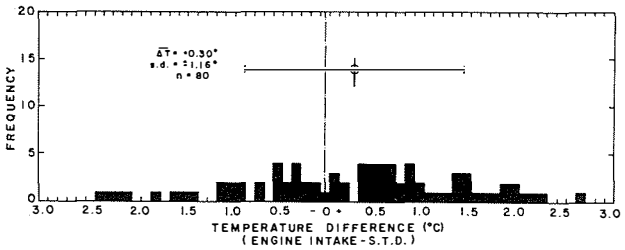
This year the efforts of the Offshore Oceanography Group have been mostly directed towards two principal problem areas, namely the large-scale interactions of atmosphere and ocean and the physical oceanography of the continental shelf north of the Strait of Georgia. This focus has not meant the exclusion of all other interests.

Climatology and Large Scale Air-Sea Interaction

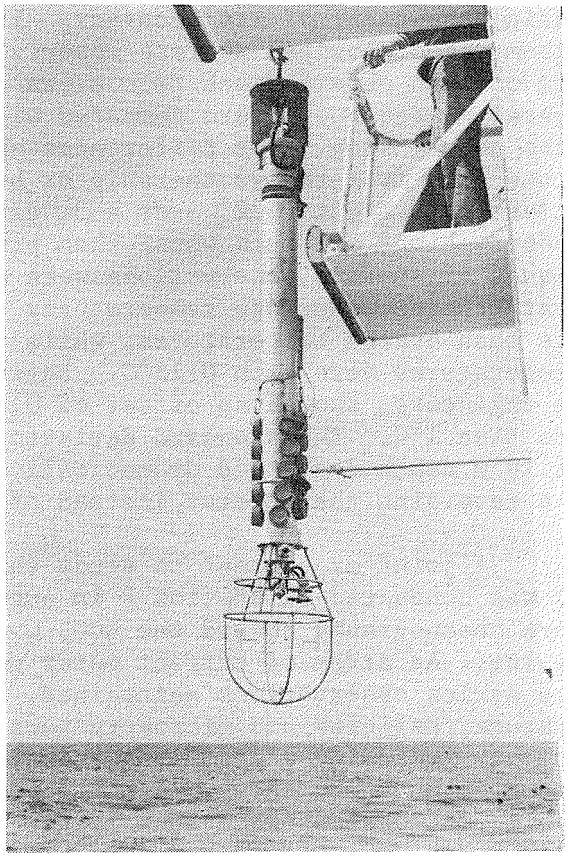
Descriptions of ocean climate and calculations of oceanic effects on atmospheric climate based on such descriptions can be no better than observations used in compiling them. A major effort over the last year has been devoted to critically examining such data in order to prepare a realistic assessment of its accuracy. The most commonly available data is that from meteorological surface observations from merchant ships. All reports of such observations from areas near Ocean Weather Station P or one of several moored buoys were compared with the data from the weathership or from the nearby buoy. The differences show a standard deviation of 1.5°C while the data from the weathership or buoys typically show standard deviations of 0.1°C to 0.2° over a 3½ day period. This indicates the ship observations are much worse than previously expected. Different techniques of surface observations were compared on a research ship and on the weatherships. Surface temperatures from XBTs were 0.3°C higher on the average than bucket temperatures, while the standard deviations of bucket and XBT temperatures were both 0.15°C. Engine room intake temperatures, as read by the engineers, showed an offset of 0.3°C together with a standard deviation of more than 1°C. The standard deviation between temperatures at the surface and at 10 m depth decreased dramatically when surface observations were made using a reversing thermometer instead of a bucket sample. (Tabata)

A joint experiment to study the dynamics of the oceanic mixed layer (MILE) was conducted at Station P in August and September by a team from Offshore Oceanography aboard the CCGS *Quadra*, and a U.S. group with two U.S. ships. An array of current meter moorings was established and a grid of time series observations maintained. Vertical profiles of velocity, temperature, salinity and microstructure were obtained with several instruments including a profiling acoustic current meter developed at the Institute of Ocean Sciences. Although only a preliminary interpretation is available, the data shows a much larger horizontal variability than expected. (Miyake)





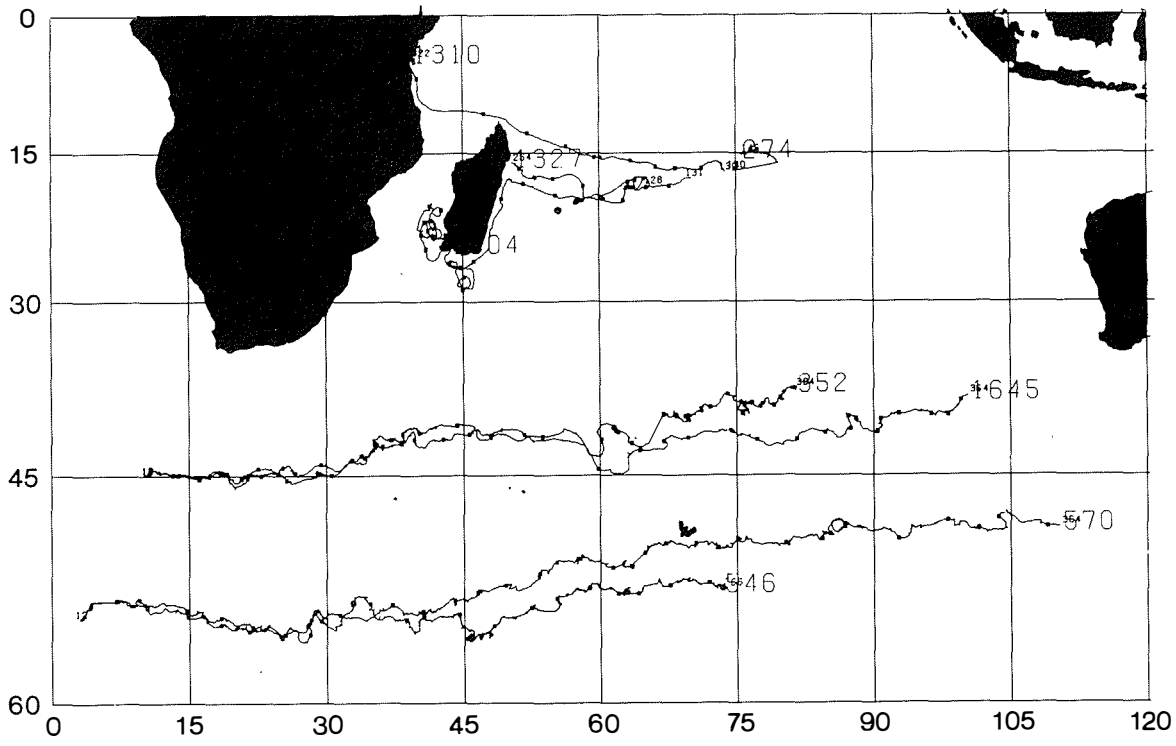
Differences between observed sea surface temperatures by bucket observation by oceanographers and reference temperatures by CTD (top) and between engine intake observations by engine-room crew and CTD reference (bottom). The engine intake temperatures are characterized by the presence of much scatter (standard deviation of ±1.2°C). This value is an order of magnitude greater than for data obtained by other methods.



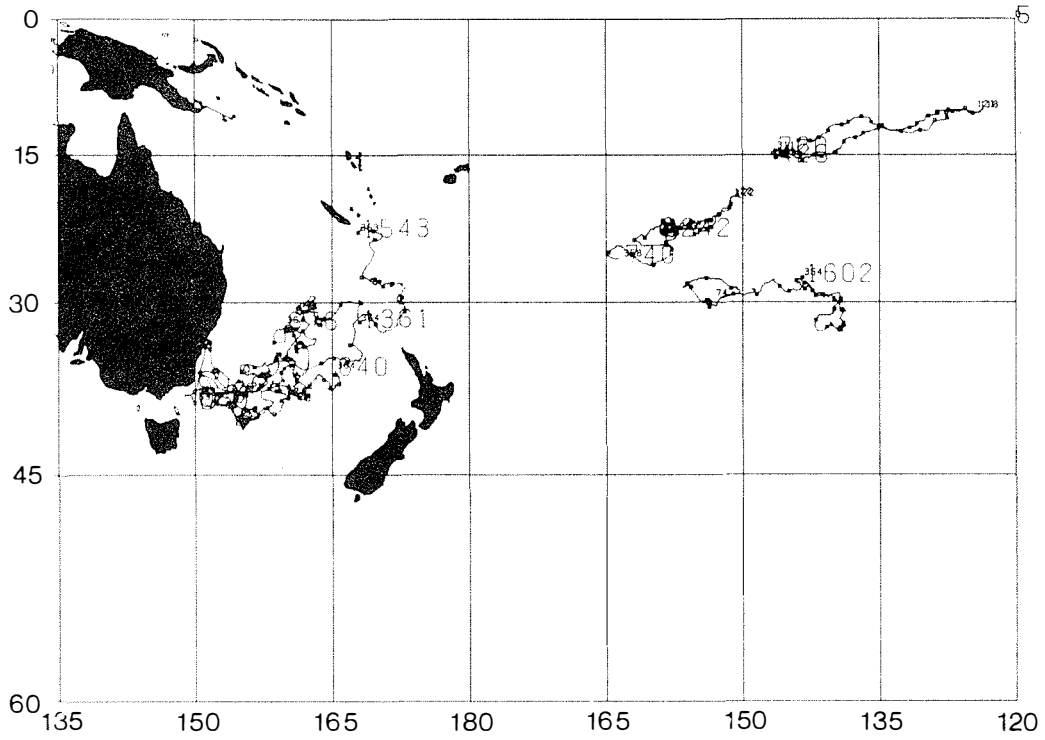
Profiling instrument developed at the Institute of Ocean Sciences being deployed from *CCGS Quadra* at Ocean Weather Station P. The instrument contains a 3-D acoustic current meter and sensors for temperature, conductivity and depth, as well as three axis accelerators.

On a somewhat larger time and space scale, data from an AXBT survey of an area between 47°N and 42°N and 166°W and 174°W repeated at two to three week intervals has been analyzed and displayed as part of the Anomaly Dynamics Study. The object of this international cooperative experiment is to study the changes occurring as a result of weather patterns to determine how important ocean currents are in the formation of large thermal anomalies such as are observed in the North Pacific, and which are thought to influence weather in North America. (Miyake)

Our part of the Canadian contribution to the First GARP Global Experiment (FGGE), or Global Weather Experiment, has lead to activities on an even larger space scale. These are related to the network of 300 drifting buoys planned for barometric pressure and sea surface temperature observations in the Southern Hemisphere during 1979. During 1977 20 prototype Canadian buoys were deployed at sea, 18 of them in the Southern Hemisphere, from the ships of five countries. The deployment points ranged from 11° South latitude to 55° South latitude and from 3° East longitude to 120° West longitude. By the end of 1977 an average of 220 days of observations had been obtained from each buoy, 9 were still operating and 7 had washed ashore. The buoy array to be used during the FGGE in 1979 will consist of 300 buoys from 8 countries which will be launched from the ships of at least 15 countries. The planning necessary to ensure that all parts of the ocean are adequately covered at the right time and to establish which ship will deploy which buoy, where, and when, has been another of our activities, in this case carried out by a contractor, Beak Consultants Ltd. Considerable effort from Offshore Oceanography has also gone into studies necessary to ensure that the data from the buoy array has the necessary accuracy and that the data processing produces the best possible data quality, as well as into the international management of the buoy observing system. (Garrett)



Tracks followed by prototypes of Canadian drifting buoys designed for use during the First GARP Global Experiment. The four southernmost tracks all represent drifts of almost one year.



Tracks followed by prototypes of Canadian drifting buoys designed for use during the First GARP Global Experiment. The "spaghetti" in the Tasman Sea results from the tracks of four buoys.

The programme of oceanographic observations from the weatherships at Ocean Weather Station P and along Line P was continued for yet another year.

Oceanography of the Continental Shelf

Work in the northern passages between Vancouver Island and the mainland continued with an active programme of current meter observations and a series of CTD observations at two month intervals. This programme, being carried out jointly with the Tidal Survey Section is aimed at producing a picture of the annual cycle in this area, as well as better information on the propagation of the tide through the network of channels. Preliminary results indicate that the most intense vertical mixing of the outflowing brackish layer and the deeper inflow occurs over the shoals in Race and Current Passages in Johnstone Strait, that there is negligible flow of water into secondary channels, and that the currents are predominantly semidiurnal (M2) but show large changes in amplitude and phase along channel.

An internal tide is apparently generated over "Newcastle Sill" in the western portion of Johnstone Strait, leading to deep currents which are twice as big as the surface currents. This tide appears to dissipate in only 10 km. Observations of the vertical structure of the velocity field were made using the Offshore Oceanography profiling acoustic current meter. A large number of sediment samples were taken in hopes of delineating the average current field by means of depositional features. (Thomson)

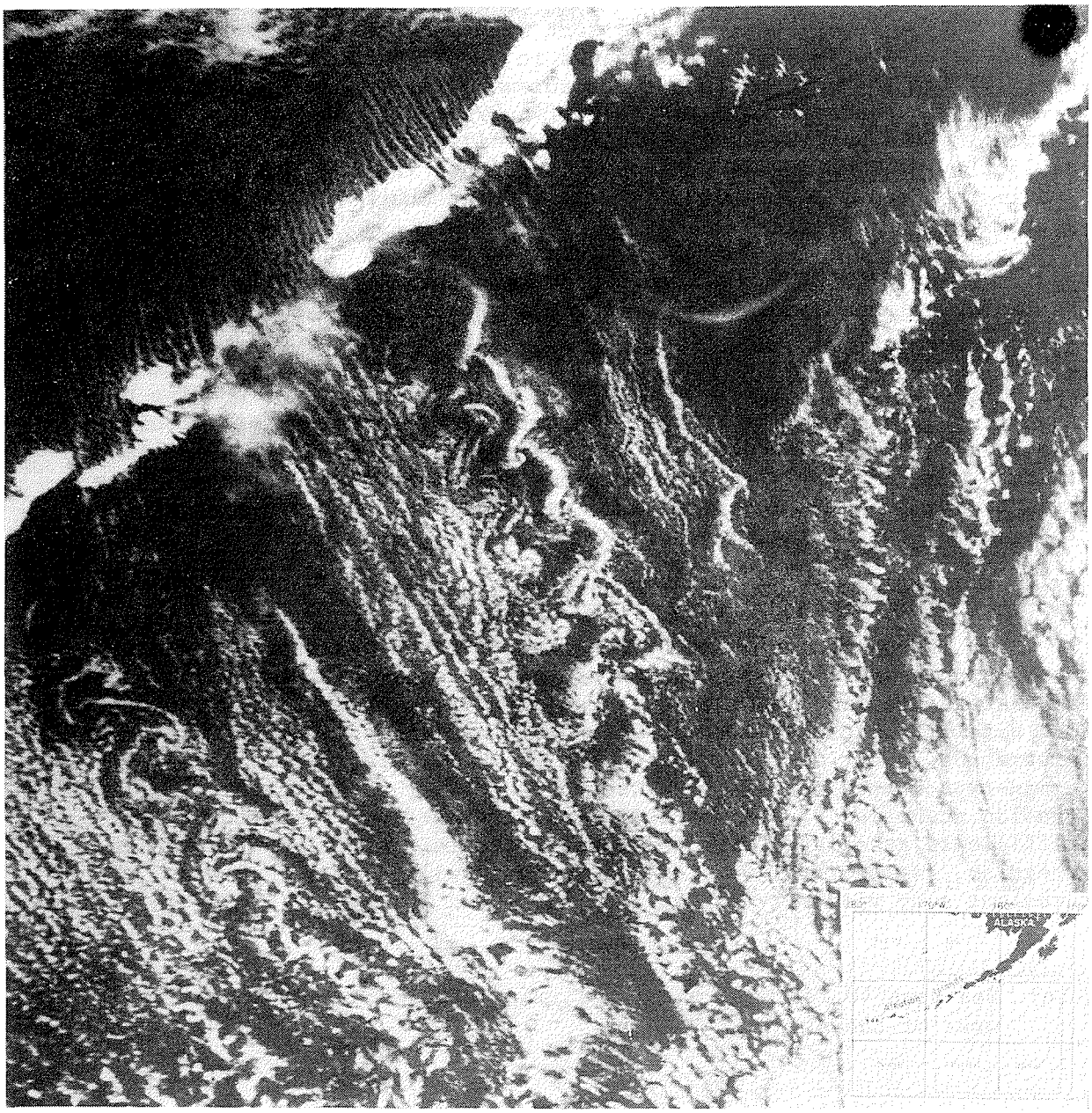
In another cooperative effort with the Tidal Survey Section current meter moorings were maintained in Queen Charlotte Sound and Hecate Strait. Wind and bottom pressure measurements were also included in this survey, which formed part of a study of currents in navigable waters leading to Kitimat, the possible site of a future oil port. Grids of CTD profiles and bottle casts were also made on 3 occasions, including two time series of CTDs in the deep channels cutting across Queen Charlotte Sound from the Pacific Ocean. (Thomson)

One result of a series of dives on the Continental Shelf made by the Geological Survey of Canada using the submersible *Pisces IV* was the discovery of ripples composed of volcanic sand and carbonate shell hash on the bottom in depths of 80 m to 105 m. Typical wavelengths for such ripples were 30-100 cm with heights of 15 to 30 cm, with the crests running nearly parallel to the coastline. These could result from the water velocities associated with long swells with periods of 12-14 seconds and heights of 4.5 to 9.0 metres arriving from the open Pacific to the southwest. The wave records from the waverider buoy near Tofino show that waves of the right period and height do occur in the area. (Thomson)

Vortex Streets in the Wake of the Aleutian Islands

The characteristics of a series of cloud-delineated wake patterns downwind of isolated mountain barriers on the Alaskan Peninsula and eastern Aleutian Islands were studied using a geometrically corrected NOAA satellite picture in conjunction with available meteorological information. Four of these wakes were shown to be atmospheric analogues of Karman-type vortex streets observed in laboratory experiments. A critical Reynolds number of 92 ± 5 was estimated for the flow, while the drag coefficients associated with the vortex streets ranged from 1.1 for an irregular, asymmetrical wake to 2.3 for a regular symmetrical wake. The turbulent eddy viscosity ranged from 1.2-1.8 x $10^3 m^2 s^{-1}$. (Thomson)

Note: See page 40 for NOAA satellite image of vortex streets in the wake of the Aleutian Islands.



NOAA satellite image of vortex streets in the wake of Aleutian Islands. Vorticies are formed downstream of larger mountain peaks in a layer of stratocumulus clouds lying below 500-1000 m elevation provided the Reynolds number of the flow exceeds a certain critical value.

NUMERICAL MODELLING

R.W. Stewart - Head

P.B. Crean
R.F. Henry
P.J. Richards - Computing Services
T.S. Murty (seconded from H.Q.)
M.G. Foreman - Computing Services

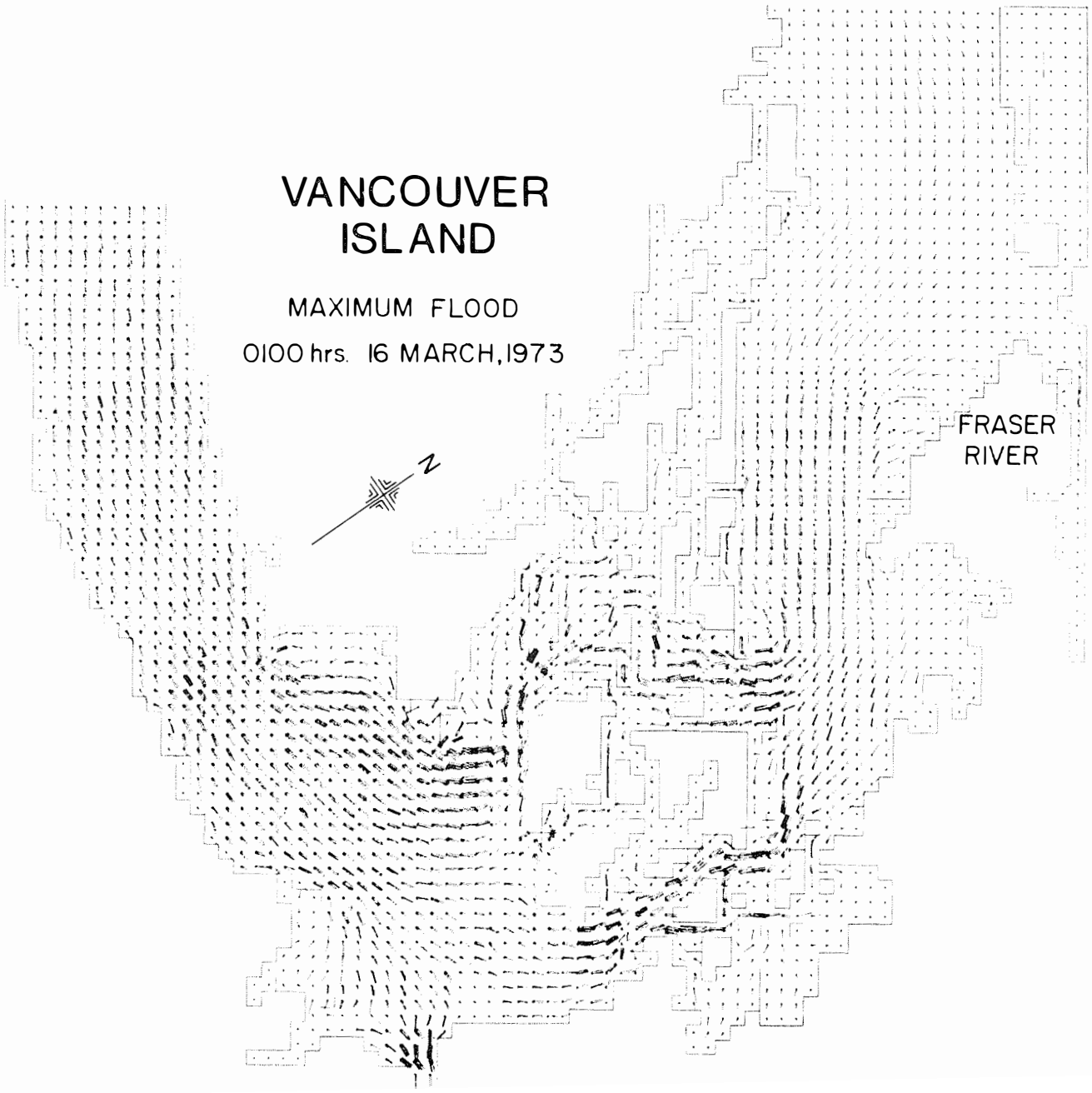
The Section continues to be involved in the development and application of numerical models for simulation of oceanographic conditions in areas of high priority.

Tides in the Queen Charlotte Sound - Hecate Strait - Dixon Entrance system have been simulated successfully using a linearized model. A technique simpler than Proudman's indirect method (proposed in 1925) has been developed to utilize available tidal observations. The results of the model will be summarized in the form of cotidal charts for the whole system.

An ocean circulation model is being developed to study enhancement of barotropic circulation by baroclinic effects.

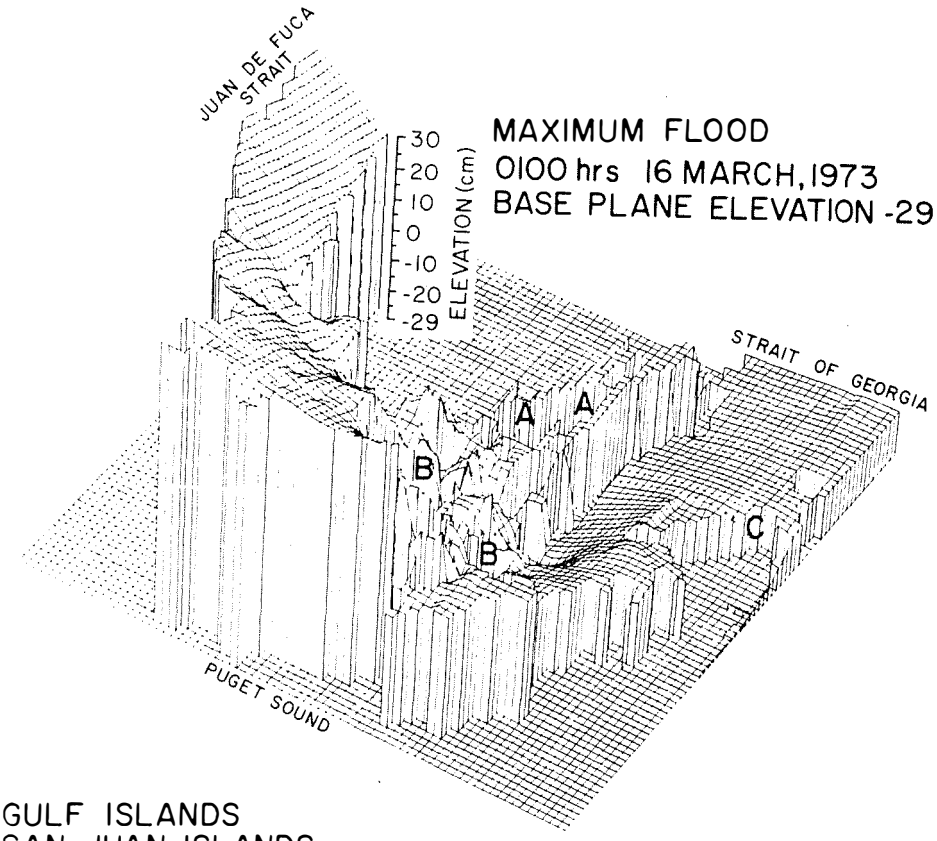
Tidal height and tidal current analysis and prediction programs used generally throughout the Department have been extensively revised and standardized.

Computed water surface elevations obtained from an overall barotropic numerical model which simulates the mixed tides between Vancouver Island and the mainland have been used to drive a more detailed model (2 km mesh size) of the southern Strait of Georgia, Juan de Fuca Strait and the region of the San Juan Islands. The tidal elevations and streams obtained from this latter model have been verified against observations for representative locations. An earlier attempt to operate such a local model using observed elevations proved unsatisfactory since its sensitivity was insufficient to permit proper frictional adjustments and also because of the inability of the tide gauges to provide adequate resolution of the small slopes along the open boundaries of the model.



Illustrative of the results obtained from this model, the figure above shows the distribution of velocity vectors when the flood streams are maximal during a tide of average range. Interesting features of these computed fields include the formation of eddies, evident along the northern shores of the inner part of Juan de Fuca Strait, which are associated with strong residual circulations.

The other figure shows the shape of the water surface for the same time as the flood streams shown above. The marked change in elevation across the San Juan Islands occurs from the heavy frictional dissipation in that area. Transverse slopes of the water surface which balance the geostrophic



accelerations of the incoming streams are evident in Juan de Fuca Strait and the Strait of Georgia.

The next major problem in these numerical model studies of the waters between Vancouver Island and the mainland concerns near-surface circulation in the Strait of Georgia. The Fraser River discharge moves out over the salt water in the Strait to form a shallow upper layer which is highly sensitive to the changing tides, river discharge and winds. The costs of numerical experimentation required for the study of so complex a physical system are greatly reduced if the water surface slopes and the underlying barotropic tidal velocities obtained from the above 2 km mesh model can be introduced directly into a "buoyant spreading" upper layer model simulating these shallow motions. A successful exploratory study has been completed demonstrating the efficacy of this technique. This is a continuing joint study with Dr. J. Stronach and Dr. Paul LeBlond of the Institute of Oceanography of the University of British Columbia. An accompanying program of field observations involving CSTD and current meter profiling, also drogue tracking, is being carried out using the Canadian Hydrographic Service launch *Brisk*.

REMOTE SENSING SECTION

J.F.R. Gower - Head

J.S. Wallace

The remote sensing section has responsibility for development of remote sensing techniques for oceanography and for evaluation of techniques originating elsewhere.

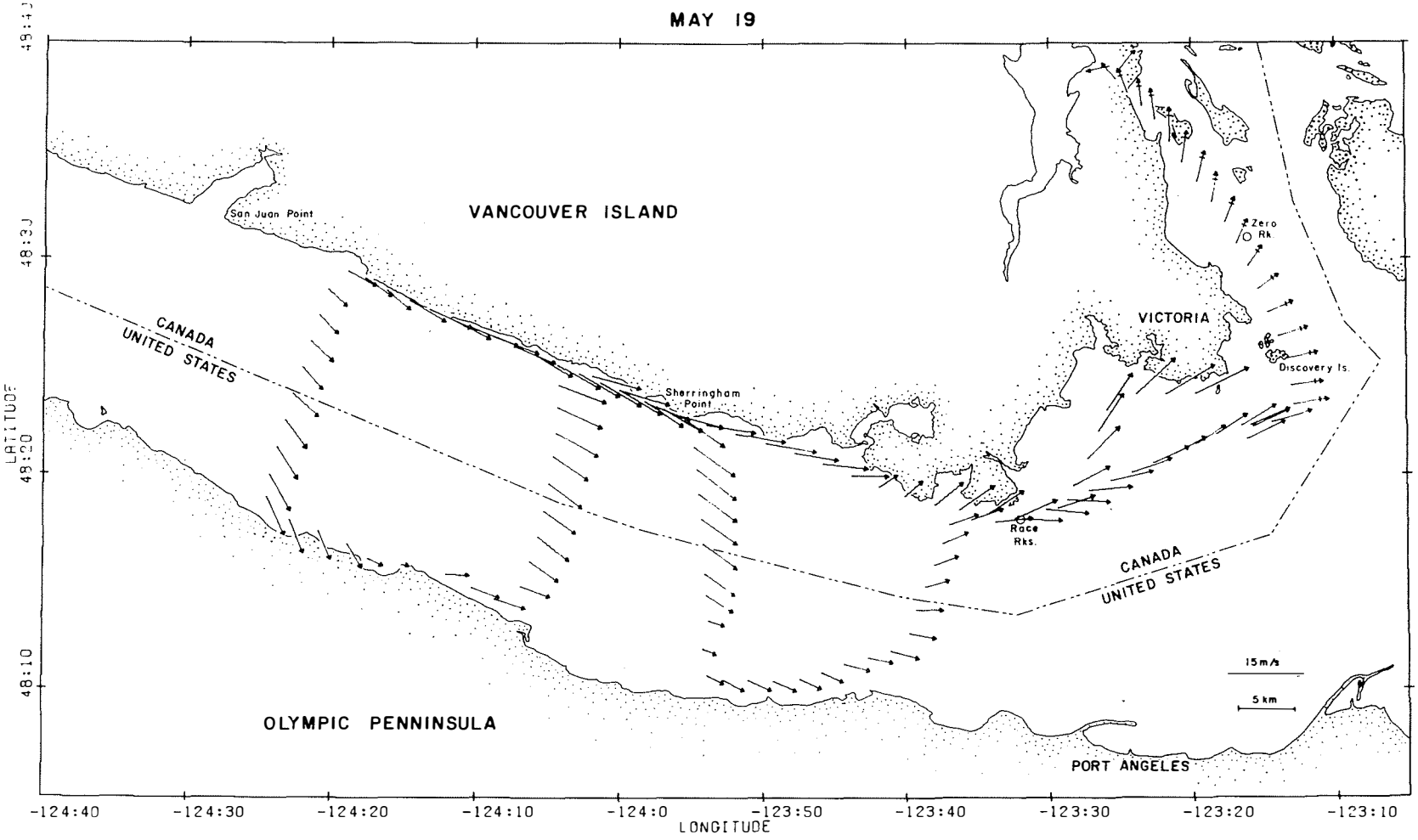
During 1977 the work of the section included projects involving measurement of waves by radar altimetry and synthetic aperture imaging radar, chlorophyll measurements by spectroscopy, mapping of near surface winds from aircraft, provision and processing of satellite imagery and provision of specialized aerial photography in support of the Institute's oceanography programs.

Satellite Oceanography

The first satellite specifically designed for studying the ocean, the United States National Atmospheric and Space Administration (NASA) SEASAT, will be launched in 1978. This has particular interest for Canada since its sensors will operate at high radio frequencies, in the microwave region of the spectrum, and therefore will not be affected by cloud cover that so frequently prevents aerial or satellite imaging using visible light over areas of interest to us. A Canadian program designed to investigate the capabilities of using satellites for surveillance (SURSAT) will evaluate SEASAT and contribute expertise to NASA's scientific planning teams for this satellite. J.F.R. Gower is a member of the team that is planning the imaging radar experiments.

Some of the potential uses of this imagery were demonstrated during an aircraft flight over the west coast of Vancouver Island when a synthetic aperture radar of the type to be launched on SEASAT produced pictures showing internal and surface wave patterns and coastal current boundaries. The wavelength deduced for the surface waves was in good agreement with data collected by the waverider buoy off Tofino. Images of similar resolution, but covering much larger areas will be provided by the satellite.

In addition to an imaging radar, SEASAT will carry a radar altimeter to measure wave and sea surface height, a scatterometer to measure sea surface wind, and a multichannel microwave scanning radiometer to measure sea surface temperature and to map ice cover. Different groups in Canada are studying the various applications of these and similar sensors. NASA has selected J.F.R. Gower to be one of the scientists to work on GEOS-3 radar altimeter data and the Remote Sensing Section has been evaluating this instrument for wave measurements and has developed an improved method of data analysis. These results will also apply for the SEASAT altimeter.



Plot of winds over Juan de Fuca Strait as measured by a low-flying aircraft. Near surface winds were measured by specially instrumented aircraft flying at less than 100 feet above the surface. Data will be used to predict the movement of oil spills under particular meteorological conditions.

Another satellite to be launched by NASA in 1978 is Nimbus G which will carry an instrument for mapping ocean colour, specifically those changes that are caused by varying amounts of floating plant life or phytoplankton in the water. The Remote Sensing Section has been evaluating the technique using a 256 channel spectrometer. During 1977 the first results of this study were published and the equipment is now being improved for further measurements in Europe and in the Arctic.

For the display and analysis of satellite imagery, the Section has put a digital picture production system into operation, which will allow special purpose enhancements to be made for a variety of ocean and Arctic projects.

Various other uses made of satellite imagery during 1977 include an analysis of vortex streets visible on the National Oceans and Atmospheric Administration (NOAA) polar and synchronous satellites and continuing observations of sea surface temperature patterns using thermal infrared scanning.

Airborne Oceanography

Operations in airborne coastal oceanography use a specially instrumented aircraft leased from the Provincial Government. During 1977 this was used principally for low level wind observations to be applied to modelling the movement of oil spills. The sighting system on the aircraft allows the positions of targets to be measured to an accuracy of 10 meters. Various tracking operations on drifting surface drogues were carried out to assist in the compilation of coastal current charts.

Other airborne work included photography of Knight Inlet to follow motion of the glacial silt repeated on 3 dates during the summer months. The silt colours the water very strongly and indicates fronts and internal waves as well as tidal currents.

ARCTIC MARINE SCIENCE

A.R. Milne - Head

B.D. Smiley R.H. Herlinveaux

Arctic activities in 1977 centred on the Beaufort Sea, the Sverdrup Basin in the Queen Elizabeth Islands, and Lancaster Sound at the eastern end of the Northwest Passage. These activities related mostly to marine oil-spill countermeasures and oceanography in support of environmental assessment requirements, and to a lesser extent, marine biology. Many of these activities were supported by the Polar Continental Shelf Project of Department of Energy Mines and Resources.

The Beaufort Sea

Four overview reports of the Beaufort Sea Project are in various stages of completion; two were published in 1977. These are: Oil Spill Countermeasures, and Birds and Marine Mammals. Demand for over 40 technical reports remained high, mainly on account of accelerated exploratory drilling in the Beaufort Sea by CanMar and from the many investigators engaged in the Alaskan Outer Continental Shelf Environment Assessment Program.

Plans to deploy 17 Random Access Memory Data Buoys around the rim of the Beaufort Sea were developed late in the year with buoy deployment by Twin-Otter expected early in January 1978. These will be complemented by several installed in the southern Beaufort Sea within drilling permit areas by CanMar and Imperial Oil (Canada) Ltd. and plans include use of remote sensing by aircraft. Several buoys, equipped with air pressure sensors, will add to meteorological data necessary to interpret ice drift. Objectives are to measure velocity shears in transition ice zones, to identify regions of ice which may enter petroleum exploration areas in summer and, to investigate characteristics of ice motion peculiar to the Beaufort Sea off M'Clure Strait.

Wave-rider buoys were again deployed in the southern Beaufort Sea in summertime in cooperation with Imperial Oil, Gulf Oil and CanMar. These were located off Kugmallet Bay, Pullen Island, Garry Island, Warren Pt. and CanMar drillships. Data from these buoys is available through the Marine Environmental Data Service (MEDS) in Ottawa.

Sverdrup Basin

The existence of oil at Cameron Island motivated the Department of Indian and Northern Affairs (DINA) to request studies on oil-spill pathways from possible oil pollution in the Sverdrup Basin. Several studies, partly funded by DINA, were initiated and included: (i) radar tracking of sea ice north of Byam Martin Island near an anticipated oil pathway,

Radar installation used for tracking ice in Arctic channels

(ii) a satellite imagery study of ice movement, encompassing several years' images, from which oil pollution trajectories were inferred and (iii) a longer-term study to analyze existing oceanographic data in the region to interpret water movements. Reports are presently available for the first two of these. A report on winter oceanography in Wellington Channel and eastern Barrow Strait will be available in January, 1978.

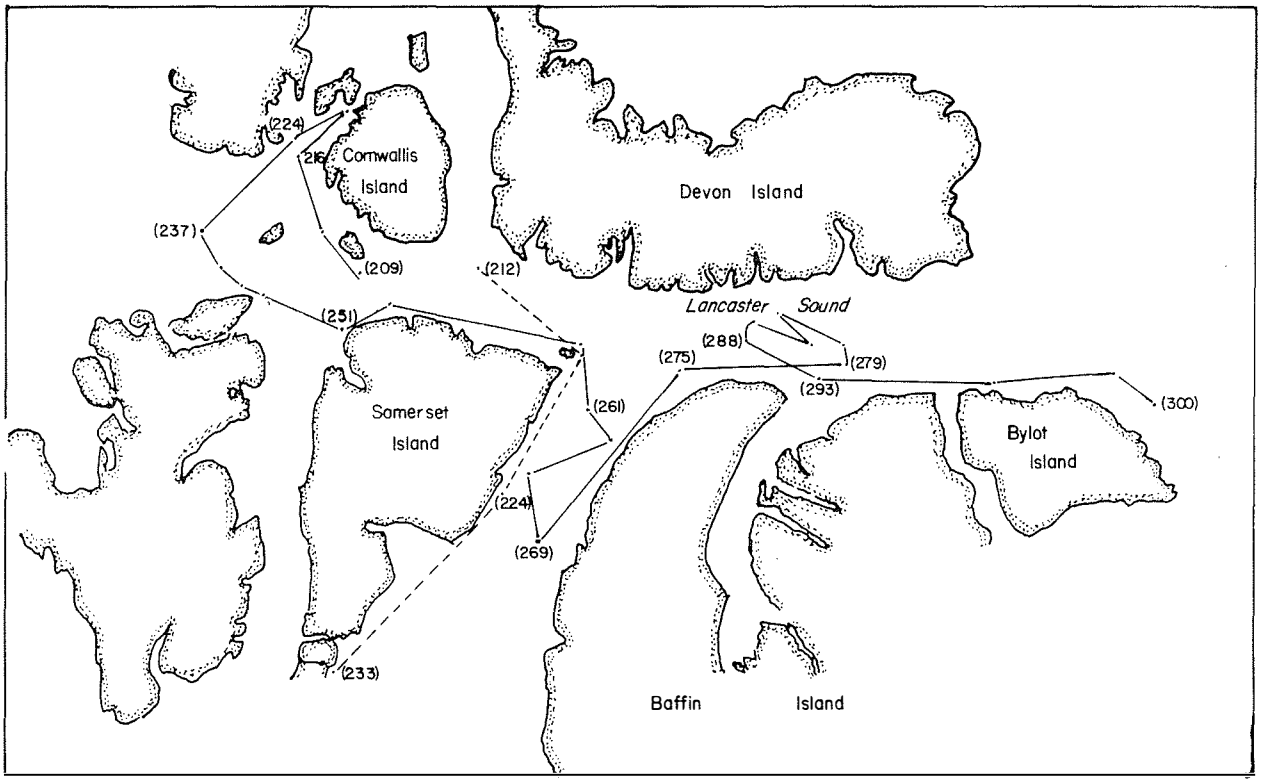
Oilspill countermeasure problems in multiyear ice focussed on the problem of how to deal with oil trapped under it. Oil under first year ice rises to the surface in early summer through brine channels and capillaries. The question was - when would it surface through multiyear ice? The Environmental Protection Service (EPS) funded a study on the seasonal variability of the porosity of multiyear ice. It was surmised that oil would likely surface in late September, when the body of the ice is warmest. To test this hypothesis the porosity of multiyear ice was measured at various times of the year. Findings indicated that in late September, or earlier, one would expect oil which was trapped under multiyear ice during the previous winter to surface.

Lancaster Sound

The environmental impact statement on possible effects of offshore drilling in Lancaster Sound is slated for completion in January 1978 and has been the most time-consuming work for two investigators during 1977. The considerable attention devoted to this assessment is warranted by the consensus that Lancaster Sound is by far one of the most biologically productive regions in the Canadian Arctic. Funding support for this task was provided by DINA.

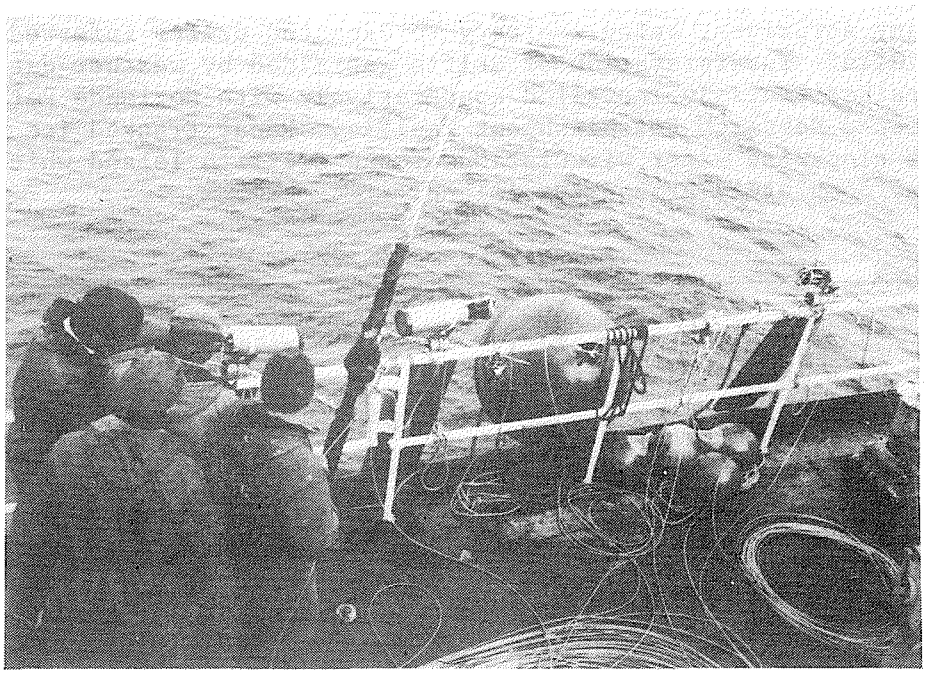
Surface water movement studies in Lancaster Sound were funded by Environmental Protection Service under their Arctic Marine Oilspill Program (AMOP) and are related to the determination of oilspill trajectories. These comprised three main components: tracking drift-buoys in the open water of summer, tracking sea ice by radar through the breakup period from Griffith Island, in Barrow Strait, and complementary satellite imagery and meteorological studies of ice drift and surface water movements.

Ten drift-buoys, tracked by NOAA satellite, were deployed in eastern Barrow Strait at intervals during the summer. Their drifts provided many surprises, being contrary to expected drifts inferred from historical data. Interpretation of drifts was aided by weather data from portable weather stations installed cooperatively with Norlands Petroleum and the Defence Research Establishment Pacific. Radar tracked ice floes confirmed a clockwise water circulation around Griffith Island which moved a drift-buoy completely around the island.

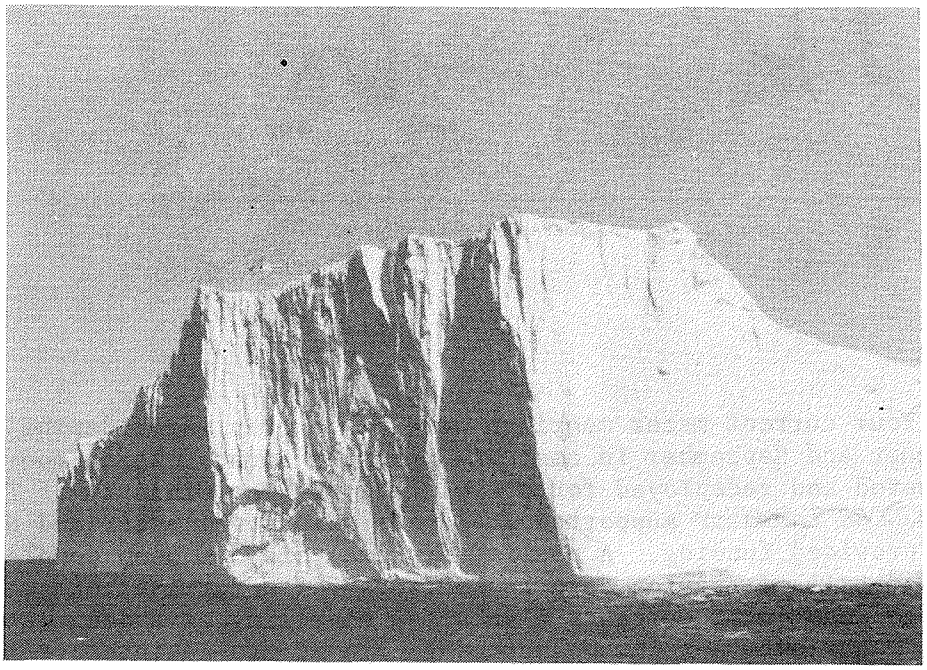


Drift-tracks of two of the COSRAM satellite buoys.

Four current-meter moorings were set out in water depths of 750 m during August and September in eastern Lancaster Sound. Three moorings were recovered and redeployed for overwintering. The Ministry of Transport icebreaker *CCGS Labrador* supported field operations while EPS and Norlands Petroleum provided funding. A preliminary analysis has been completed in sufficient detail to provide data to Norlands for underwater oil-well drilling design. The deep-water currents also allow modelling of a deep-water oil-well blowout and shallower current measurements are of use in interpreting iceberg drift.



Current meters and buoys layed out on rail of *CCGS Labrador* ready for mooring in 750 meters in Lancaster Sound



"Equipment eating" icebergs in Lancaster Sound

OCEAN CHEMISTRY DIVISION

C.S. Wong - Chief of Division

W.J. Cretney
R.W. Macdonald
J.A.J. Thompson
R.D. Bellegay
W.K. Johnson
F.A. McLaughlin
P.S. Munro
D.W. Paton
D. Macdonald
J.S. Page (Computer Services)
T. Soutar (Chemical Instruments)
V. Stukas (Postdoctoral Fellow)
K. Iseki (Postdoctoral Fellow)

Visiting scientists:

K. Kremling (Institut für Meereskunde, University of Kiel, F.R.G.)
E. Matsumoto (Geological Survey of Japan)
R. Schmidt (Meteorological Institute, Frankfürt, F.R.G.)
D. Cossa (France; now at Rimouski University, Quebec)
J. Puize (Peches et Sciences de la Mer, Quebec)

Ocean Chemistry Division's primary responsibility is to understand the chemical aspects of the marine environment in B.C. coastal waters, the western Arctic and N.E. Pacific Ocean, and to assess the chemical effects of human activities on seawater, suspended matter and bottom sediments. These effects must be distinguished from large natural and often non-systematic variations. A secondary role is to provide chemical oceanographic information useful in fisheries research, in geological studies and in the study of water transport and mixing.

The major event for the Division is the final move to new facilities at Patricia Bay after a 1972 transfer from Nanaimo to a temporary location at 211 Harbour Rd. in downtown Victoria. These new laboratories include unique clean rooms for trace metals, hydrocarbons and pesticide studies, an underground vault for radiocarbon and lead-210 geochronology, mass spectrometer rooms, infrared calibrating and analytical areas, plus basic chemical laboratories for nutrients, heavy metals and oceanographic parameters. By joining other groups already at the Institute, a more fruitful interaction with other disciplines is anticipated.

Coastal Pollution, Bio-Uptake

(Thompson, Paton, Cretney, McLaughlin)

Point-source pollution by domestic and industrial outflows into the coastal environment has been a major concern of the public and regulatory agencies, such as the federal Environmental Protection Service (EPS) and the provincial Pollution Control Board. Problem areas include sewage outfalls at Macaulay Point and Clover Point where the City of Victoria is discharging domestic wastes, mining disposal sites in Howe Sound and Quatsino Sound and the ocean dumpsite at Point Grey in the Strait of Georgia. Chemists look at

the concentration of toxic compounds, both inorganic and organic, accumulated in the biota and in particular those in marine benthic organisms to assess if an overall danger level of pollutants is being taken up by the benthic food web.

Public hearings on waste disposal by mining industries in B.C. were held in Victoria recently, attended by Dr. Thompson, who assisted the government team in the inquiry by providing his expertise in heavy metal pollution gained from his studies at Britannia Mines in Howe Sound and Utah Mines in Quatsino Sound.

Bioaccumulation work was mainly supported by Ocean Dumping funds in the Point Grey dumpsite study. Data on heavy metals in marine benthic organisms in 1976-77 showed insignificant differences between the dumpsite and a control area nearby. The data was, however, insufficient statistically. Thus, a cruise was conducted in July 1977 to collect surface sediments, clams and mussels near the dumpsite, and also off the Victoria city sewage outfalls, for analysis of heavy metals (such as lead, zinc, copper, mercury, cadmium, chromium and arsenic) and organic pollutants (polychlorinated biphenyls and petroleum hydrocarbons). Some mussel collections were made along Juan de Fuca Strait for heavy metal studies and for baseline levels of petroleum hydrocarbons prior to heavy tanker traffic from Alaska.

Biotransformation of metal compounds, especially the methylation of mercury, is important in metal pollution problems. Under Ocean Dumping studies, field coring was conducted in Howe Sound. Much higher total mercury and methylmercury occurred near the chlor-alkali plant at Squamish, but methylmercury, the more toxic form, amounts to low values of less than 9 $\mu g\ kg^{-1}$ or 1% of total mercury. Laboratory biomethylation studies using radioactive ^{203}Hg tracer at 15°C demonstrated rapid methylation in the first 5 days, reaching a steady-state maximum in 10-25 days, then decreasing afterwards. Similar laboratory studies were conducted for Alberni sediments, which appeared to methylate much faster than Howe Sound sediments.

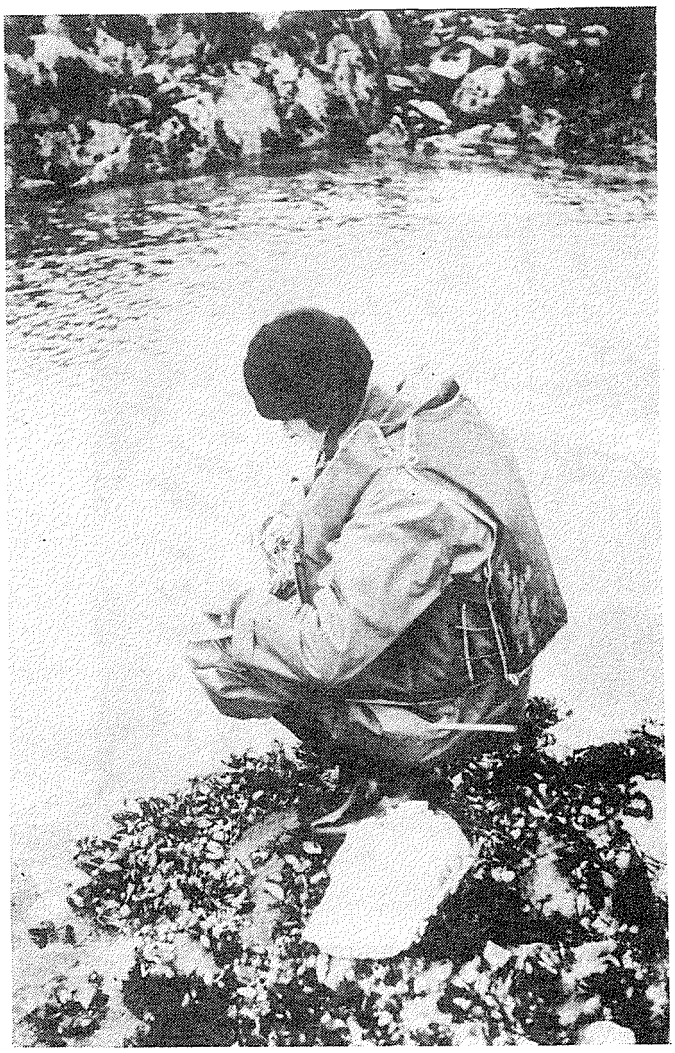
Chemical Oceanography

(R.W. Macdonald, Johnson, D. Macdonald, Bellegay, Munro, Wong, Barry)

To collect Arctic baseline data in the Amundsen Gulf area, chemical oceanographic and environmental studies were conducted on board the *Pandora II* in August, 1977 on a ship-of-opportunity basis in conjunction with the major hydrographic program. Seawater, surface sediment and plankton samples were collected for hydrocarbons and trace metals. Shipboard mercury determinations in seawater indicated low background levels similar to those in the Southern Beaufort Sea. Lack of strong influence from the Mackenzie River was evident from the high salinity. Similar nutrient maxima features to those observed in our 1975 Beaufort Sea studies confirmed the source of the Northern Beaufort Sea sub-surface shelf water to be from the Amundsen Gulf.

Coastal cruises were conducted approximately once per month in B.C. coastal waters for environmental studies. During February 4-16, a *Parizeau* cruise was carried out in the Kitimat-Porpoise Harbour area to obtain

seawater and zooplankton samples for hydrocarbons. Mussels were collected around Douglas Channel during beach walks by the landing party. Lead-210 dating of a core in the area suggested a high sedimentation rate of about 0.5 cm yr^{-1}, a fact which will strongly influence the fate of future contaminants introduced into the area. Three cruises were dispatched to the Alberni Inlet for work related to Ocean Dumping. Oxygen depletion in the Inlet was found above Stamp Narrows, but could not be related specifically to the effect of dumping. Cores and grab samples showed bark and wood chips overlying the upper inlet bottom, suggesting that such material from log booming grounds is more significant in causing de-oxygenation than dumping at the designated site. Summer oxygen depletion occurred in Howe Sound this year, a rare event in the past few decades. Several cruises were conducted throughout the year to study the oxygen changes and other possible chemical effects. No change in mercury levels in the water and anoxic sediments were detected. The severe de-oxygenation has caused mass mortality in the marine benthic fauna. The event could not be explained satisfactorily, although it was thought to be related to circulation affected by the abnormal Squamish River outflow.



Collecting mussels, Kitimat,1977

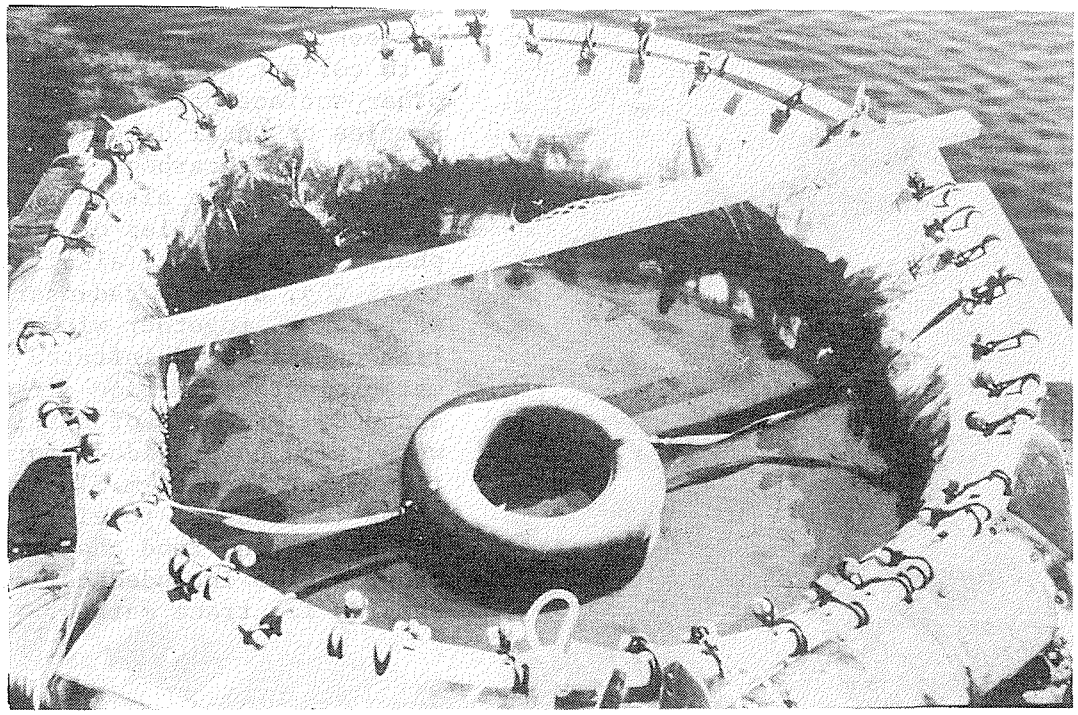
Open-ocean effort was devoted to a continuing study of the long-term trends of chemical parameters at Ocean Weather Station P (50°N, 145°W). Neuston net tows were made between Victoria and Station P to collect tar balls and other surface pollutants. Samples of total dissolved aromatic hydrocarbons in surface waters were also collected. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2, surface radiocarbon were taken, together with continuous shipboard infrared measurements of marine air CO_2 and pCO_2. Samples of nutrients were taken to provide information about long-term fluctuations in relation to circulation and the marine food chain. The program also included collecting samples for trace metals.

Marine Hydrocarbons & Pesticides

(Cretney, Christensen, McLaughlin, R.W. Macdonald, Wong)

The objective of the program is to understand the occurrence, pathways and fate of hydrocarbons (natural, petroleum, polychlorinated byphenyls (PCBs) and pesticides) in the marine environment. The main effort was on a Controlled Ecosystem Pollution Experiment (CEPEX) to study the behaviour of emulsified oil and on establishing clean-room techniques for PCBs.

To understand the behaviour of Prudhoe Bay crude oil emulsified with a new commercial dispersant, Corexit 9527, a CEPEX experiment, funded by the Environmental Emergency Branch of EPS in Ottawa, was carried out September 26 to October 13 in Saanich Inlet. Instruments were developed on a crash basis for the study: an underwater photomicrographic apparatus to detect oil droplets in the micron diameter range, a modified small-size National Bureau of Standards (NBS) sampler to sample under slicks and a continuous flow-through fluorescence device capable of detecting 0.1 parts per million of emulsified oil. One large plastic bag, with about 60,000 liters of seawater, was spiked with 3 liters of Prudhoe Bay crude oil as a control and another with the crude oil emulsified with 150 ml of the dispersant. Results showed the dispersant to be effective immediately.



A CEPEX enclosure into which has been poured a mixture of Corexit 9527 in Prudhoe Bay crude oil

Underwater photomicrography apparatus

However, in 1-2 weeks, the emulsion flocculated to loose aggregates up to 1 cm across. Even after 2 days, the emulsified oil tended to lose chemical activity. Work is still in progress to perform gas chromatographic analysis on the samples and to construct an eddy diffusion model to explain the spread of emulsified oil into the water column.

Long-term weathering of oil spilled by the grounding of the ship *Irish Stardust* at Alert Bay in 1974 was summarized after a recent visit to assess the latest environmental changes. This summary was presented at a Halifax Symposium on Long-Term Fate of Oil in September, 1977. Oil composition, in particular cyclic triterpanes, was utilized in following the chemical degradation of the oil.

PCBs have been one of the more serious environmental concerns in recent years becuase of their persistence and toxicity in the environment. Analytical techniques are being developed using a gas chromatography with an electron-capture detector and gas chromatograph-mass spectrometer using all clean-room precautions to identify PCBs and pesticides in samples from local B.C. waters. One such study of the sediments in Porpoise Harbour, Prince Rupert, affected by a PCB spill by Cancel Ltd. was undertaken.

Trace Metals

(Wong, Kremling, Piuze, Matsumoto, R.W. Macdonald, Johnson, Stukas)

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

For seawater, the key problem is the reliability of the sampling and analysis of trace metals at the ultra-trace levels. This analytical problem is crucial in our assessment of the state of the environment in the pristine waters of the Arctic and in open oceans, as well as in an understanding of trace metals released into seawater from sediments and particulates including material dumped into the ocean in concentrations approaching natural levels. Work funded by NATO is in progress on accurate measurements using clean rooms and mass spectrometry in cooperation with Dr. Kremling of Kiel, F.R.G. and Dr. J.P. Riley of Department of Oceanography, University of Liverpool.

Our main emphasis is on mercury. In response to an EPS western Canada mercury assessment, preliminary data were compiled for B.C. coastal waters: 8 nanograms per litre (ng ℓ^{-1}) in Howe Sound, 10 in Saanich Inlet and 21-29 in Alberni, Rupert and Neroutsos Inlets. These low levels indicated efficient removal mechanisms from seawater, since the Howe Sound waters sampled were near a chlor-alkali plant. A sediment survey of mercury contents suggested a low background level of 0.05 µg g^{-1} near the Squamish River estuary but "hot spots" of 7 µg g^{-1} were found around the plant. Another hot spot of over 1 µg g^{-1}, detected in a sediment layer between sand 4 and 20 cm below the sediment surface off Watts Point in Howe Sound, was shown by lead-210 geochronology to be relict, introduced at least 40 years ago.

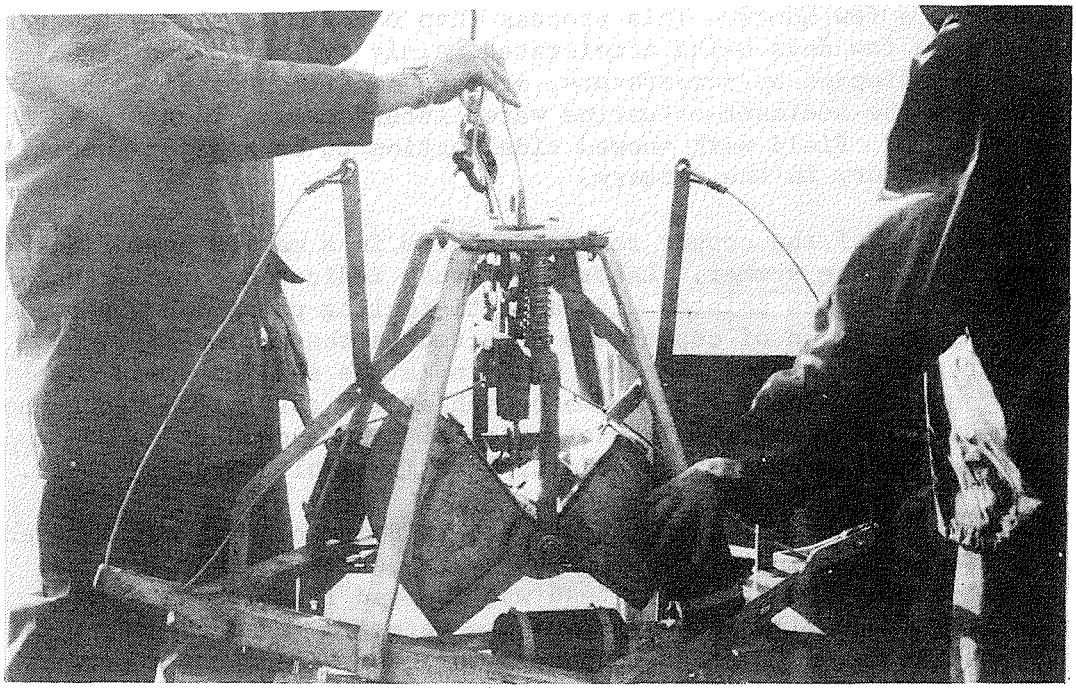
Sampling dredge spoils in Victoria's Inner Harbour for Determination of trace metals, hydrocarbons and other environmental contaminants

Mercury release from resuspended sediment in Howe Sound contaminated with mercury was studied in the laboratory as part of Ocean Dumping work. Mercury release occurred rapidly from suspended sediment into seawater within a few hours. This process then moved more slowly towards equilibrium in a few days being accelerated mainly by low pH and high salinity but unaffected by temperature, storage condition or biology. The flux across the sediment-estuarine water interface was found to be about 100 ng cm^{-1} day^{-1}. Field work showed tidal action to be a major mobilizing mechanism for mercury in the estuary.

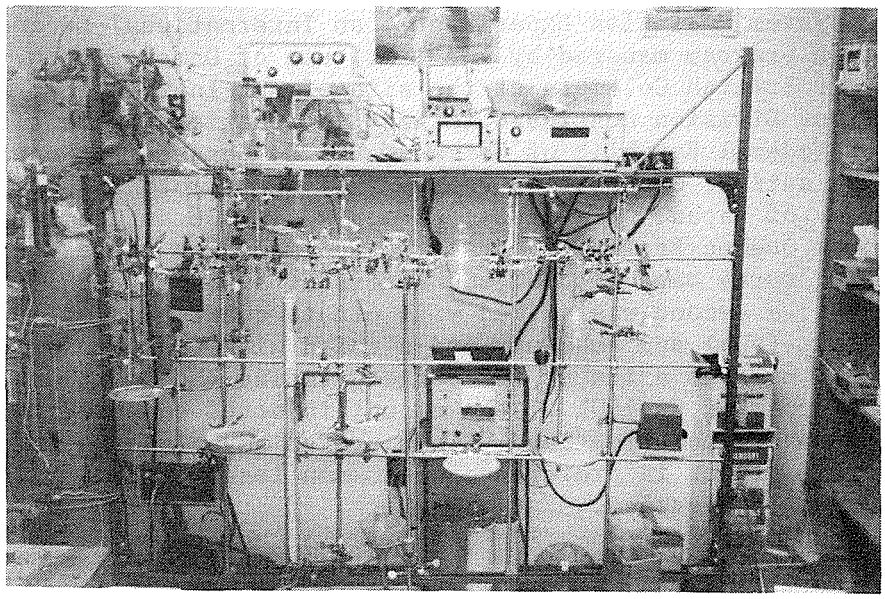
A survey of the copper release problem in a marina near Sidney was carried out in the summer. Laboratory study indicated a rapid leaching of copper from a surface painted with an anti-fouling paint. However, no significant accumulation of copper was detected in the marina sediments. A project on accumulation of tetraethyl lead in marine sediments was also initiated by establishing a gas-chromatograph/atomic absorption technique and isotope dilution technique for detection of minute quantities of tetraethyl lead and the isotopic ratio of lead in gasoline respectively.

The trace metal sedimentation rate in Saanich Inlet was studied by using a lead-210 dating method together with determination of trace metal concentrations in seawater. Lead was removed from the water very rapidly. A residence time of 0.08 years was inferred for lead-210, 0.07 for other lead isotopes, 0.3 for copper, 3 for cadmium and 2 for mercury in the coastal inlet. These residence time scales were in line with preliminary results of CEPEX work here, where lead added at the parts per billion level to the water was quickly removed as detritus in the first 5 days, and where any cadmium added would have less than 1 percent removed after almost one month.

Our Division is in our fourth year of association with CEPEX (Controlled Ecosystem Pollution Experiment), an International Decade of Ocean Exploration program managed by the Institute of Oceanography, of the University of British Columbia at the site of our Institute at Patricia Bay. Our Division continued to host international scientists: Dr. Kremling of Federal Republic of Germany, Dr. D. Cossa of France under a Canada/France Scientific Cooperation Program, Dr. Matsumoto from the Geological Survey of Japan. Dr. Piuze, formerly with Ocean Chemistry, also participated from Quebec Region. A tracer experiment was conducted August 6-26 using three bags with 60,000 liters of seawater each. One was used as a control, a second was spiked with minute quantities of lead-210 (1.5 micro Curries (μC)) and cadmium, and a third with 0.5 μC of radiocarbon. Isotopic lead-210 used as a tracer for budget studies showed a much better recovery in the order of 85-100% of the amount injected compared to a much lower value for non-radioactive lead. This proved advantageous in its continued use as a tracer in preference to common lead. Work is still in progress on data processing.



Smith-McIntyre sediment grab sampling
at the Port Alberni ocean dump site



Apparatus for total CO_2 extraction from
seawater samples from the weatherships at Station PAPA

Marine Carbon Cycle

(Wong, Bellegay, Munro, Iseki, Page, Rennie)

The global carbon cycle is receiving much attention in the scientific community because of man's increasing reliance on fossil fuel sources due to population pressure and strong public reactions to nuclear power as an alternative. There are serious debates on the possibility of climatic warming as a result of an atmospheric carbon dioxide (CO_2) increase, on the relative importance of the biota and the ocean as a CO_2 sink and on the political and economic consequences of turning to coal as our energy source after depletion of petroleum. Scientific challenges are encountered in our quests for solutions in these energy-related debates. The on-going research in Ocean Chemistry is contributing some new insights into the marine aspects of the global carbon cycle in attempts to meet such challenges.

The CO_2 time-series at Ocean Weather Station P (50°N 145°W) is in the ninth year of documenting the increase in background atmospheric CO_2 over the ocean. It forms an important data base for our understanding of air-sea CO_2 interaction. By analysis of the CO_2 content in weekly air samples and continuous air and seawater partial pressure of carbon dioxide (pCO_2) measurements by infrared instruments, we detected an unexpected static CO_2 level in both 1975 and 1976 contrary to the currently accepted notion of atmospheric CO_2 increase. This implies some uncertainty in our knowledge of how atmospheric CO_2 behaves and throws models of CO_2 prediction in the atmosphere into serious doubt. Another unexpected finding is the much higher pCO_2 in surface waters than in the air at Station P in the summer, contrary to the accepted concept of the ocean waters in northern latitudes acting as a CO_2 sink in summer. These findings were presented in the Seattle International Association of Meteorology and Atmospheric Physics on the Carbon Cycle.

The most recent efforts to compile an accurate inventory of sources of atmospheric CO_2 for use in constructing global CO_2 models, have unexpectedly indicated that contributions derived from forest fires and tropical shifting cultivation are more important than previously thought, being at least 30% of the present-day burning of coal, gas, petroleum and limestone. A new hypothesis advocating enhanced marine detritus formation as a CO_2 removal mechanism has been proposed as an alternative to the known CO_2 sinks, namely the ocean and the land biota. Dr. K. Iseki of Tohoku University in Japan joined Ocean Chemistry in late 1977 to start work related to detritus carbon for evidence of such mechanisms by planning detritus carbon time-series experiments at Ocean Weather Station P, and marine detritus carbon studies using CEPEX enclosures.

In addition to Station P CO_2 analysis, our infrared laboratory has been performing air CO_2 analysis and reference gas calibrations 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. Instrument development was pursued under a NATO grant, in cooperation with Dr. R. Schmidt of Meteorological Institute at Frankfürt, Federal Republic of Germany on adapting his water-correcting CO_2 analyzer to measurements of partial pressure of CO_2 in seawater and for air-sea CO_2 flux studies using aircraft.

OCEAN ECOLOGY LABORATORY

R.O. Brinkhurst - Head

M.J. Austin
K. Denman
G. Gardner (Postdoctoral Fellow)
D. Mackas (Postdoctoral Fellow)
P. Chapman (Graduate Student)

In its second year the Ocean Ecology Laboratory (OEL) moved from the hangar to an old cottage and then into the new Institute building. Dr. Ken Denman joined the laboratory, transferring from the Marine Ecology Laboratory of the Bedford Institute of Oceanography, as did Dr. Dave Mackas from Dalhousie University on a Visiting Fellowship. With increased allocation of summer students, and recent Federal Labour Intensive Programme technicians plus internal allocation of a term technician OEL has been able to pursue an active field program as well as laboratory investigations and planning of future projects.

In February 1977 Ocean Ecology Laboratory hosted a workshop to investigate the feasibility of using regularly scheduled commercial ships and tankers (ships-of-opportunity) to collect, in a cost-effective manner, the large amount of data needed for a long time series of biological, physical and chemical oceanographic information from B.C. coastal and shelf waters. Local representatives from the universities, industry and government as well as scientists from the United States and Britain attended. One of the conclusions identified a need in the Region for a time-series of oceanographic and biological information along the Canadian shelf to provide background for studies of ocean climate, environmental disturbances such as build-up of hydrocarbons or CO_2 level changes in the atmosphere, and for fisheries managers seeking anomalies that can be related to survival of young fish at sea. The combination of severe weather and lack of adequate platforms has made the shelf difficult of access, and this remains the major problem.

Since then discussions and planning have continued, and it is hoped that a pilot field program will be initiated before the end of 1978 in cooperation with Dr. T.R. Parsons, Institute of Oceanography, University of British Columbia.

To complement the ships-of-opportunity program, several projects have been initiated within OEL.

Dr. Gardner led two cruises to the major mainland inlets and nearshore coastal waters north to Dixon Entrance. Data from these cruises provide the first extensive characterization of British Columbia marine zooplankton communities. Without this fundamental information we can only guess at the impact of man-made and natural environmental changes on fisheries and other coastal resources.

Two shorter cruises, utilizing the University of Victoria's motor launch *John Strickland*, were carried out along a line of stations from the Strait of Juan de Fuca to the Strait of Georgia near Nanaimo. These cruises examined the effect on the zooplankton of the annual intrusion of offshore water into the Strait of Georgia. Long term changes in the composition of the intruding water appear to contribute to long term changes in the zooplankton community of the Strait; however, the mechanisms responsible for the changes are as yet unknown. In addition, intruding water may transport zooplankters normally found offshore into inshore waters, and be responsible for maintaining populations of some of these species locally.

The above studies were designed to establish baseline data which will be used to plan further, more intensive, programs. The long term goal of this aspect of the plankton program is to increase our understanding both of the processes involved in zooplankton community evolution and of food chain interactions within the communities.

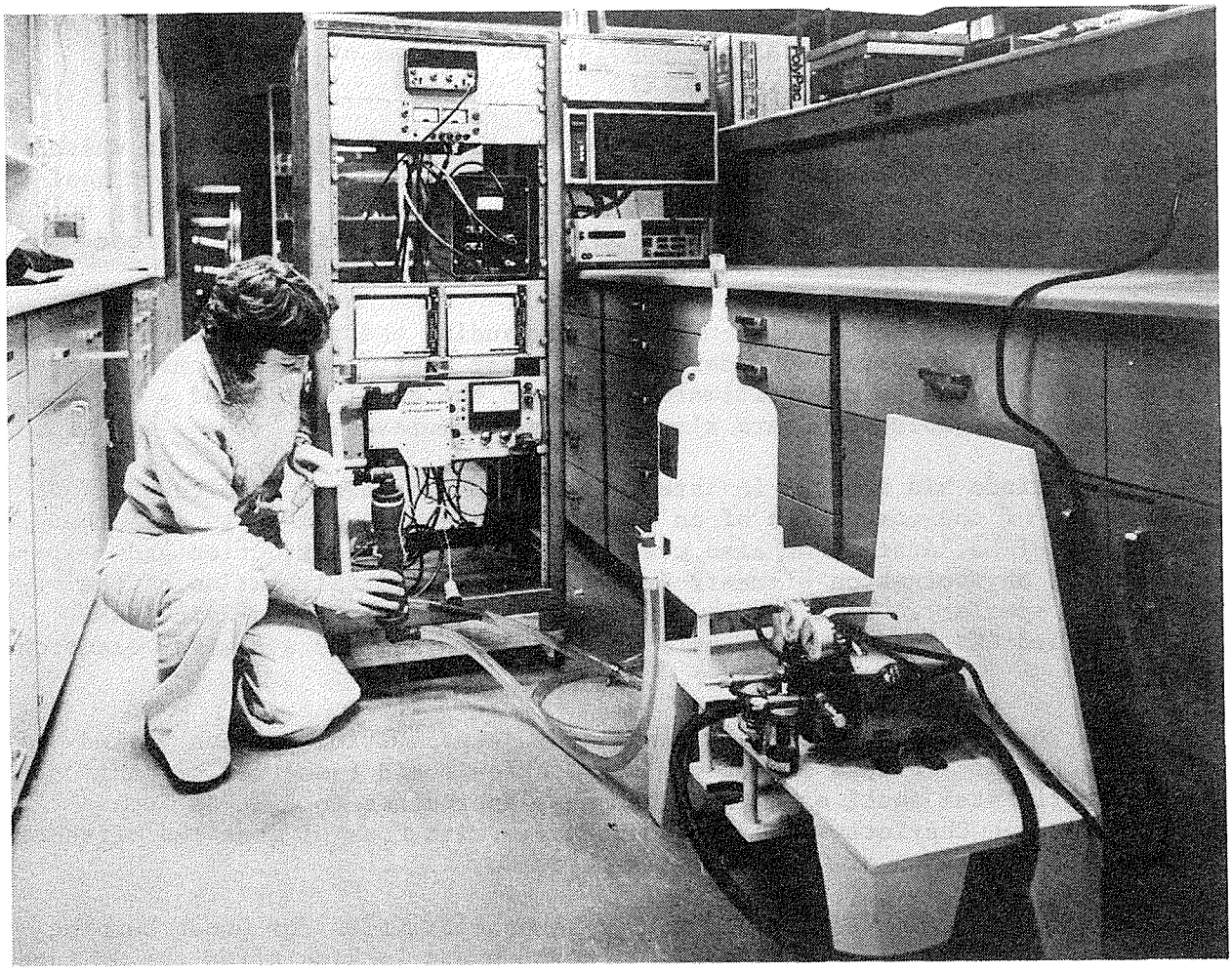
Progress has also been made in expanding the zooplankton species reference collection started under contract last year. Descriptions of the species, which we hope will ultimately lead to the construction of a new key to B.C. marine zooplankton, are slowly being accumulated.

Since his arrival in late June, Dr. Mackas has assembled and tested most of the components of an electronic plankton sampler. With the assistance of Ms. Austin, he also evaluated methods for extraction and analysis of phytoplankton pigments (required for field calibration of the electronic sampler). He spent 1½ months with the joint Canada-Peru ICANE cruise aboard CSS *Baffin*, where he operated and maintained a similar electronic system.

Dr. Denman is actively planning a joint multidisciplinary study of the oceanographic factors affecting the planktonic and fisheries production on the continental shelf of either the outer approaches to Juan de Fuca Strait or Queen Charlotte Sound in cooperation with Coastal Zone and Offshore Oceanography Sections of Ocean Physics Division.

In addition to administrative responsibilities for Ocean Dumping operations and research, running the laboratory and looking after the Science Subvention program and summer students for the Institute, Dr. Brinkhurst has maintained an active field and laboratory program. Material from overseas has led to the completion of a study of the zoogeography of oligochaeta in Europe, a study of rare and interesting Tasmanian species, and completion of a first review of the Canadian fauna. Work has begun on a revision of the marine oligochaetes of the world. In laboratory work he and Ms. Austin were finally able to complete a long study of energy flow through worm communities by obtaining reasonable estimates of ingestion of food by these animals that mineralize organic sludge or silt. The study of the bottom fauna of the Fraser suggests that the concentration of salt in the bottom mud responds quite slowly to changes in the water column salinity, and so

the transition zone between the freshwater and saltwater species is quite sharp and seems to shift seasonally in relation to run-off and tidal rhythms. Mr. Chapman is carrying out experimental work based on his field results.



Electronic plankton sampler

On an invitation from the Pacific Geoscience Center, the Lab is attempting to identify the benthos on their photographs of the sea bed on the continental shelf and slope. This may lead to identifying benthic communities on a broad scale.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

F.S. Green - Assistant Marine Superintendent (Deck)
D. Marr - Assistant Marine Superintendent (Engineering) to September 17, 1977
R.W. Parkinson - Assistant Marine Superintendent (Engineering) from December 1, 1977

Mr. D. Marr, Assistant Marine Superintendent (Engineering) retired from the department September 17, 1977. His position has been filled by R.W. Parkinson, Chief Engineer *Parizeau*. Mr. G. Kyle has been promoted to Chief Engineer *Parizeau*.

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1977 hydrographic and scientific programs and for several federal departments and universities.

CSS *PARIZEAU* (64.3 m overall - 1929 metric tons)

Master: A.G. Chamberlain Chief Engineer: R.W. Parkinson

Following annual drydocking and refit at Yarrows Ltd., Victoria, B.C., CSS *Parizeau* was employed in support of scientific and hydrographic programs, Ocean and Aquatic Sciences, Tides and Currents, Ocean Chemistry, Loran 'C' calibration, Offshore Oceanography; Defence Research Establishment Pacific, Ocean Acoustics; Department of National Defence, diver training; Simon Fraser University, Biology.

She was converted to hydrographic configuration and carried out hydrographic surveying in the Caamano Sound area from June 15 to August 31, 1977. She was then converted to tidal oceanographic configuration and carried out various scientific programs.

CSS *WM. J. STEWART* (65 m - 1720 metric tons)

The *Wm. J. Stewart* is decommissioned at the Patricia Bay wharf. The Ship Division office moved from here into the new Institute office during the latter part of May.

CSS *VECTOR* (39.6 m - 505 metric tons)

Master: J.C. Marston Chief Engineer: J.J. Peat

The CSS *Vector's* annual drydocking and refit was carried out at Yarrows Ltd., Victoria, B.C. During the year she carried out the following programs for Ocean and Aquatic Sciences, Ocean Chemistry, Loran 'C' calibration;

for Pacific Environment Institute, Biology, Ecology; for Institute of Oceanography, University of British Columbia, Physics; for Environmental Protection Service, Biology; for Energy Mines and Resources, Earth Physics.

CSS *RICHARDSON* (19.8 m - 76 metric tons)

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

The CSS *Richardson's* annual refit was carried out at Burrard Shipyard and Marine Railway, Vancouver, B.C. During the year she carried out the following programs for Ocean and Aquatic Sciences, Side scan sonar, Coastal Oceanography, Tides and Currents, Revisory Survey; for Energy Mines and Resources, Geology, Side scan sonar; for Defence Research Establishment Pacific, Instrument testing; for Pacific Environment Institute, Ecology; for Inland Waters Directorate, Water quality.

M.V. *RADIUM EXPRESS* (22.2 m - 100 metric tons) on charter

Master: J.P. O'Sullivan Chief Engineer: W. Riggs

This vessel carried out a successful survey season covering the Mackenzie River and Mackenzie Bay areas.

M.V. *PANDORA II* (58.2 m - 220 metric tons) on charter

Master: R. Jones Chief Engineer: C. Tuck

The *Pandora II* with *Pisces IV* were employed in the following programs for Ocean and Aquatic Sciences, *Pisces IV* pilot training and certification, Ecology, Coastal Oceanography, Ocean Chemistry; for U.Vic. Biology; for Environmental Protection Service, Biology; Energy Mines and Resources, Ecology and Geology; for Institute of Oceanography, University of British Columbia, Sediment sampling.

She departed Patricia Bay for the Western Arctic June 30, arriving at the survey area in Amundsen Gulf July 25. The survey program was terminated and the vessel departed the area September 10, arriving at Patricia Bay September 27.

She was employed in a recovery program for United States Environmental Protection Agency off San Francisco from October 13 to November 1.

PISCES IV (6.1 m - 12 metric tons)

Chief Pilot: I. Sanderson

The *Pisces IV*, a deep diving submersible, was engaged in training three new pilots, a sponge study for the University of Victoria, a survey of ocean dumpsites for Environmental Protection Service, a geological survey of the continental shelf for Energy, Mines and Resources, and a simulated gas well blowout for Frozen Sea Research Group. In August she was flown to

Resolute Bay in a D.N.D Hercules aircraft and operated from *HMCS Preserver* in support of a Defense Research Establishment Pacific program.

A new improved ballast system was installed and all the syntactic foam on the submersible was replaced. A major refit saw the submersible completely disassembled, inspected and re-assembled.

CSL *REVISOR* (11 m - 10 metric tons)

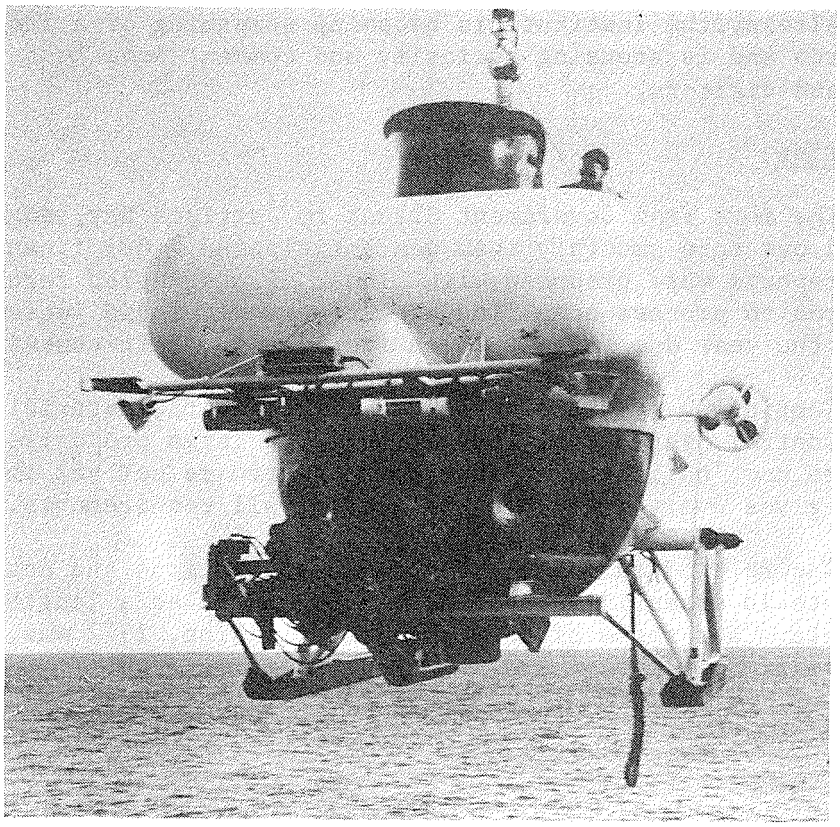
The launch *Revisor* was used in various minor programs and was used by the Canadian Wildlife Service for seabird surveys in the Strait of Georgia.

LAUNCHES

Survey launches were employed by shore-based hydrographic survey parties working in Vancouver Harbour and Saanich Inlet areas.

DEPOT

The depot workshops provided full support to all Institute groups, supplying mechanical repairs in the shop and in the field, metal fabrication, furniture building and fulfilling a multitude of requests.



Submersible, *Pisces IV*

MANAGEMENT SERVICES DIVISION

N.A. Todd - Chief of Management Services

Institute of Ocean Sciences - Construction

The end of the construction program is almost in sight. We had a good year in 1977 with no work stoppages of any consequence and construction pretty well on schedule.

Ocean Physics Division and Ship Division Management moved into their new premises in May. Hydrography and Management Services moved from downtown Victoria to Pat Bay at the beginning of September. Ocean Chemistry will joint the remainder of us at Pat Bay in January, 1978. At that time all of the units making up Ocean and Aquatic Sciences, Pacific Region will be under the one roof for the first time.

With the approval in August by the Treasury Board of an additional $1.4 million, completion of all the essential components of the Institute came within reach and we are now able to look forward to being able to walk on grass and not mud and to eat a hot mid-day meal in the Cafeteria.

Already the Institute is becoming something of a landmark in the Victoria area and is arousing curiosity and comment (mostly favourable) from residents and visitors.

Administration

The move from Government Street to Patricia Bay, some 30 kilometers, was carried out more smoothly than was anticipated. Our financial statements and other reports were produced with almost uninterrupted regularity. The time required to process some financial transactions did increase towards the end of the year due largely to an increase in their number.

Continuing progress was made in getting the Materiel Management Inventory Control System fully operational. A large proportion of the sections are now 'on line'. Although the system is not yet thoroughly proven, it gives every indication of meeting all requirements.

The role of administration in the operations and activities of the Institute is essentially a support role and makes a lengthy report here inappropriate. For those of us within the Division, 1977 was, all in all, not a bad year.

LIBRARY

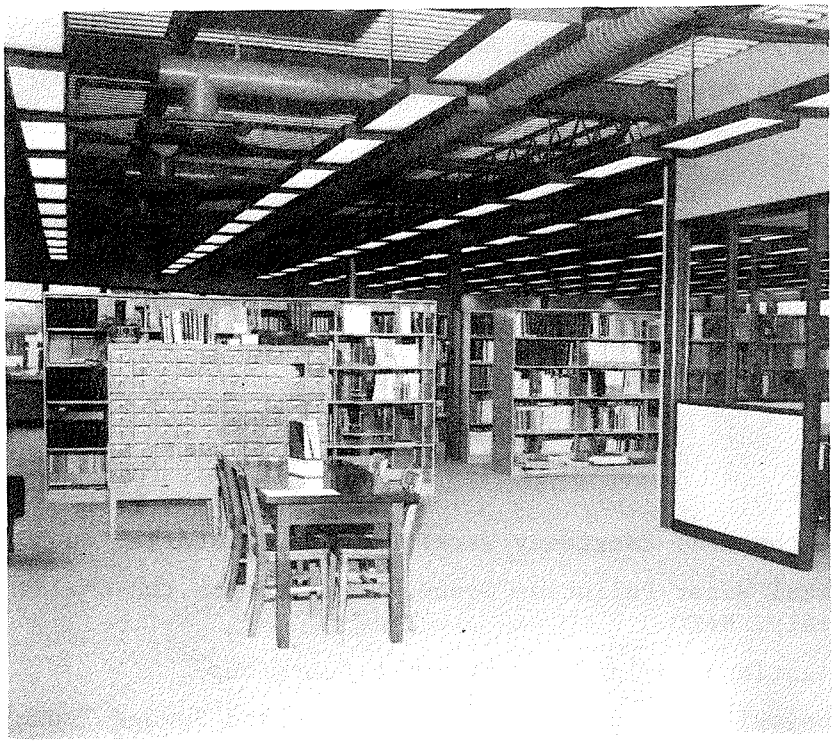
Sharon Thomson - Librarian

C. Firth

1977 was a banner year! After five years of planning and making do with crowded conditions the Library moved to its spacious new quarters in the Institute. We have at last been able to recall the various office collections and house them all in one space, making things much more accessible to all users. Losses, though large, were not as great as we had anticipated.

The increases in book and journal prices, accompanied by a sharp decline in the Canadian dollar have forced very careful examination of all purchases, but the collection has continued to grow. Eliminating some duplicate subscriptions needed when we were in so many locations has enabled us to increase the number of journal titles received.

1978 promises to be a very exciting year, too. We expect to incorporate the bulk of the Ocean Chemistry collection when that group moves here early in the year and we expect significant increases in our holdings and in the subject areas covered when the collections of Earth Physics Branch and part of the Geological Survey of Canada are received and incorporated.



TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

DIRECTOR-GENERAL'S OFFICE

Stewart, R.W.

- Joint Organizing Committee (JOC) of the Global Atmospheric Research Program (GARP)
- Canadian National Scientific Committee for GARP
- Scientific Committee on Oceanic Research (SCOR) - member executive committee
- SCOR - IAMAP - IAPSO Working Group on Air-Sea Interaction Research (COSPAR) - Canadian delegate
- Sea Use Council (Canada-USA) - vice-chairman
- Regional Board, Pacific Region (DOE)
- Regional Board, Pacific Region, Executive Committee - A/chairman
- Regional Board, Western and Northern (DOE)
- National Research Council of Canada - GARP Grants Advisory Committee
- Physical Oceanographic Commission (IAPSO) - president
- Arctic Environmental Steering Committee
- Arctic Waters Oil and Gas Advisory Committee
- Royal Society of Canada Interdisciplinary Selection Committee
- Vancouver International Airport Panel Member
- American Meteorological Society - Councillor

Cornford, A.B.

- Canadian representative to the Intergovernmental Oceanographic Commission (IOC)
- Working Committee for Global Investigations of Pollution in the Marine Environment (GIPME)

HYDROGRAPHIC DIVISION

Ages, A.B.

- Environmental Emergency Working Group, Victoria Zone
- Coastal Water Pollution Group, Committee on the Challenges of Modern Society, NATO
- Navigational Relative Risk Index Sub-group
- Technical Committee (DOE), Annacis Island Sewage Treatment

Bolton, M.

Canadian Institute of Surveying - Councillor-at-Large
DOE Kitimat Oil Pipeline Working Group
DOE Mackenzie Basin Committee
Hydrographic Committee CIS - chairman
National Cartographic Appraisal Board
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 - 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

O'Connor, A.D.

Canadian Institute of Surveying, Victoria Branch - chairman

Rapatz, W.J.

B.C. Civil Defense Tsunami Committee
Ocean Dumping Act - inspector

Sandilands, R.W.

Hydrographic Technical Committee, Canadian Institute of Surveying
The Canadian Surveyor - associate editor (hydrography)
Canadian Hydrographic Association - associate editor
Survey Technology Advisory Committee - Camosun College
Workshop Group on Offshore Surveys for Mineral Resource Development
Board of Trustees, Maritime Museum of B.C. - immediate past chairman
International Hydrographic Technical Conference Committee (1979) - member

Smithers, F.R.

Public Information Group, DOE Pacific
Regional Committee on Interagency Routing of Navigational Information
Advisory Board, Camosun College

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.

Appointed, during 1977 as National Representative to the International Coordination Group for the Tsunami Warning System in the Pacific

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Laboratory Safety Committee, Ocean Chemistry - chairman

Macdonald, R.W.

Ocean Dumping Technical Committee, Pacific Region

Thompson, J.A.J.

Pat Bay Safety Committee
Laboratory Safety Committee, Ocean Chemistry
Pacific Nuclear Activation Research Association

Wong, C.S.

Advisory Committee - Chemistry, CEPEX
Environmental Contaminant Act Advisory Committee, Pacific Region

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.

Hon Prof. - University of Victoria
Canadian Society of Zoologists - Chairman, Science Policy Committee
Regional Ocean Dumping Committee - OAS Representative
Science Subvention Program Review Committee - Regional OAS Representative
Standards Council of Canada - ISO/TC 147/ Sc 5
Local Arrangements Chairman - A.S.L. Oligochaete meetings, Victoria 1978
Chairman, First International Aquatic Symposium 1979
Graduate Students, U. Victoria, U. New Brunswick

Denman, K.L.

Canadian Meteorological and Oceanographic Society Citations Committee

OCEAN PHYSICS DIVISION

Farmer, D.M.

Babine Lake Steering Committee
RODAC Technical Subcommittee
Canadian Meteorological Society, Oceanographic Division - Chairman

Garrett, J.F.

Canadian National Committee for SCOR
Committee of Participants for the Drifting Buoy System for the FGGE (Chairman)
Subgroup of Experts on Products and Services of IGOSS for the FGGE

Giovando, L.F.

Joint Working Committee Lower Fraser River Environmental Monitoring
B.C. Coastal Zone Resource Subcommittee
Roberts Bank Environmental Subcommittee

Gower, J.F.R.

Canadian Advisory Committee on Remote Sensing, Working Group on Oceanography - chairman
National Research Council Associate Committee on Space Research
NASA SEASAT Synthetic Aperture Radar Experiment Team - associate member
DOE Committee on Remote Sensing

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 Subcommittee
Marine Science Communications - Editorial Advisory Board

Milne, A.R.

Arctic Marine Oilspill Program Advisory; Committee member
Arctic Islands Pipeline Project Studies; Board member
Polar Gas Pipeline Project; EARP panel member
Arctic Region Ocean Dumping Advisory Committee member
Canadian Advisory Committee on Remote Sensing, Working Group on Ice

Miyake, M.

Canadian GARP Scientific Committee
NCAR Aircraft Facility Evaluation Committee
Executive Committee Mixed Layer Experiment, U.S. Office of Naval Research
Associate Editor "Boundary Layer Meteorology"
Honarary Associate Professor - Institute of Oceanography, Univ. of B.C.

Nasmyth, P.W.

Joint Group of Experts for IGOSS - Subject Leader
PhD. supervisory committee for Andre Langlais - UVic (Chemistry)
IOS Library Committee (Chairman)

Smiley, B.D.

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

Tabata, S.

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

Thomson, R.E.

RSCC Task Force on the Proposed Floating Dry Dock, Burrard Inlet
B.C. Climatological Coordinating Committee
Editorial Committee, Atmosphere-Ocean

OCEAN ENGINEERING

Teng, K.

West Coast Electronic Data Processing Coordinating Committee, DFE
Organizing Committee for CIPS/ACM Northwest '78 Regional Computer Conference - General co-chairman

Johns, R.E.

West Coast Electronic Data Processing Coordinating Committee, DFE
Canadian Information Processing Society, Victoria Section - Treasurer

SPECIAL SERVICES SECTION

Smith, G.R.

Advisory Board on Marine Technology, B.C. Research

SHIP DIVISION

Geldart, E.N.

Pacific Regional Resource/Survey Vessel Committee - secretary

SCIENCE RELATED CONTRACTS AWARDED IN 1977

Preparation in digital form of oceanographic data for Fraser River plume, P. Stoddart, Vancouver, B.C.	1,012
Collating and plotting of oceanographic data G. Wallace, Sidney, B.C.	950
Development of analytical techniques for measurements of concentrations of natural and anthropogenic hydrocarbons in seawater, marine organisms and marine sediments, P.A. Christensen, Sidney, B.C.	19,500
Calibration of special current meters Applied Microsystems Ltd., Victoria, B.C.	445
Development of a computer program for hydraulic research Apocalypse Enterprises Inc., Victoria, B.C.	19,440
Development of a timing system for Pisces IV stabilizing fins Canadian Aircraft Products, Richmond, B.C.	5,453
Study of the amplitude and phase of a tidal constituent on open boundary of a coastal area I. Barodale, Victoria, B.C.	2,500
Development and design of an electronic clock for unattended tide gauges Applied Microsystems, Victoria, B.C.	5,375
Analysis of tidal and current data obtained in Harbours and Estuaries A. Harrison, Victoria, B.C.	3,876
Feasibility study on the international Ship-of-Opportunity program to obtain plankton and oceanographic data for long-range fisheries forecasts D.L. Mackas, Halifax, N.S.	540
Chemical support to the Institute of Ocean Sciences Seakem Oceanography Ltd., Sidney, B.C.	5,257

Investigation of cause of electrical failure of shore power connection from CSS Parizeau Case Existological Labs Ltd., Victoria, B.C.	2,296
Preparation of data and oceanographic diagrams C. Wallace, Sidney, B.C.	2,931
Collection and Analysis of beach sediments containing petroleum residues Seakem Oceanography Ltd., Victoria, B.C.	1,505
Biological and oceanographic research support to the Institute of Ocean Sciences University of Victoria, Victoria, B.C.	15,000
Study of Ice and water movements in Lancaster Sound and vicinity Arctic Sciences Ltd., Saanichton, B.C.	80,109
Oceanographic support to the Institute of Ocean Sciences Dobrocky Seatech Ltd., Victoria, B.C.	35,000
Development of Installation drawings and specifications for UNIVAC 1106 at the Institute of Ocean Sciences Pacific Rim Consultants Ltd., Vancouver, B.C.	6,400
Water properties sampling and measurement program aboard the CGS Vancouver at Ocean Station P Seakem Oceanography Ltd, Sidney, B.C.	49,986
Beaufort Sea wave climate study Seakem Oceanography Ltd., Sidney, B.C.	2,588
Radar tracking of ice in the Barrow Strait region of Parry Channel, N.W.T. Seakem Oceanography Ltd., Sidney, B.C.	42,142
Oceanic water properties sampling and measurements aboard CGS Quadra and chemical analysis Seakem Oceanography Ltd, Sidney, B.C.	67,000
Design and operation of the lead-210 tracer experiment under the Controlled Ecosystem Pollution Experiment University of B.C., Vancouver, B.C.	3,370
Collection and supply of hydrographic field data for correcting and up-dating navigational charts and sailing directions I.J. Campbell, Sidney, B.C.	12,620
Reduction and plotting of Knight Inlet oceanographic data Seakem Oceanography Ltd., Sidney, B.C.	16,000

Oceanographic Support for current, tide and depth surveys and tide gauge servicing in Knight Inlet C.R. Charters Ltd., Nanaimo, B.C.	14,000
Deployment and logistics planning and coordination for Global Atmospheric Research Program, (GARP) First GARP Global Experiment. Beak Consultants Ltd., Vancouver, B.C.	99,819
Oceanographic support to place instrument moorings in Knight Inlet Dobrocky Seatech Ltd., Victoria, B.C.	12,615
Data preparation and drafting for oceanographic data collected in Johnstone Strait during 1976 and 1977 cruises E.C. Luscombe, Sidney, B.C.	6,000
Preparation of check standards for the analysis of water samples for nutrients, alkalinity, trace metals and hydrocarbons, including preparation of calibration graphs, establishment of procedures, flow of work and times for analysis. L. Barry, Victoria, B.C.	3,015
Preparation of maps, graphs and drawings for report on the Environmental Assessment of Offshore drilling in Lancaster Sound Custom Drafting, Victoria, B.C.	13,410
Design of turbulence measuring equipment mount to Pisces IV Stockdale and Associates, Victoria, B.C.	2,500
Sediment and oligochaete sample collection from the Fraser River P. Chapman, Victoria, B.C.	500
Photogrammetric reduction of aerial photographs in support of the aerial hydrography project University of New Brunswick, Fredericton, N.B.	4,000
Development and fabrication of communication buoys capable of giving positional data via random access memory system communication with nimbus satellites Polar Research Laboratory Inc., Santa Barbara, Calif. U.S.A.	84,564
Study of the behaviour of the emulsified oil in sea water Seakem Oceanography Ltd., Sidney, B.C.	27,622
Collating and plotting of oceanographic data C. Wallace, Sidney, B.C.	3,000
Deep Sea recovery project of radioactive materials under the auspices of the United States Environmental Protection Agency Hyco Subsea Ltd., Vancouver, B.C.	42,000
Development and design of electronic components for a data acquisition system to be used in Pisces IV submersible Novatech Designs Ltd., Victoria, B.C.	3,199

Study to determine oceanographic energy budget for Ocean Weather Station P P.R. LaCroix, Victoria, B.C.	3,600
Identification and sorting of British Columbia marine zooplankton samples H.A. Sefton, Victoria, B.C.	4,015
Oceanographic Support for a study in Knight Inlet Ivanhoe Enterprises Ltd., Vancouver, B.C.	58,167
Development of software drivers for HP9825 to HP2100 interface Apocalypse Enterprises Ltd., Victoria, B.C.	1,125
Laboratory study of behaviour of oil and gas particles in salt water relating to deep oil well blowouts University of Calgary, Calgary Alta.	64,935
Vessel support for oceanographic activities by the Institute of Ocean Sciences Bastion City Charters Ltd., Nanaimo, B.C.	10,000
Determination of well-posed boundary conditions for numerical tidal models F. Milinazzo, Victoria, B.C.	2,000
Study of chlorophyll concentrations in sea water R.A. Neville, Sidney, B.C.	8,490
Development of computer programs for ocean mixing Apocalypse Enterprises Ltd., Victoria, B.C.	19,496
Development of computer programs for remote sensing Apocalypse Enterprises Ltd., Victoria, B.C.	12,990
Study of trace metals in B.C. coastal waters Seakem Oceanography Ltd., Sidney, B.C.	37,653
Analysis of tides at permanent tidal stations in British Columbia coastal waters Dobrocky Seatech Ltd., Victoria, B.C.	9,960
Identification and enumeration of benthic marine animals Dobrocky Seatech Ltd., Victoria, B.C.	3,455
Development and documentation of air droppable random access memory buoys in the Beaufort Sea Norcor Ltd., Yellowknife N.W.T.	22,000

Deployment of Beaufort sea drift buoys Arctic Sciences Ltd., Victoria, B.C.		4,000
		979,425
Unsolicited proposals		714,318
Ocean Dumping		79,762
		1,773,505
University	87,305	
Individuals	80,741	
	168,046	

Industry - 1,605,459

Unsolicited Proposals

Development of a direction indicating system for current meters using acoustics Caulfield-Liron Consultants Ltd., Edmonton, Alta.	222,640
Physical Oceanographic study in the Kitimat area Dobrocky Seatech Ltd., Victoria, B.C.	491,678
	714,318

Ocean Dumping

Research and record activities relating to ocean dumping on the west coast K.E. Conlon, Victoria, B.C.	6,192
Variability in analytical results on dredged spoils and marine sediments in connection with the validity of presently prescribed criteria Chemex Labs Ltd., N. Vancouver, B.C.	9,485
Analytical support for a study of mercury biotransformation in anoxic estuarine sediments Willis, Cunliffe Tait and Co. Ltd., Victoria, B.C.	3,990
Oxygen budget studies in Alberni Inlet Dobrocky Seatech Ltd., Victoria, B.C.	21,393
Collection and analysis of seawater and undisturbed sediment cores in Alberni Inlet Chemex Labs Ltd., North Vancouver, B.C.	5,415
Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni Beak Consultants Ltd., Vancouver, B.C.	27,085
Chemical and physical analysis of samples containing wood debris (ocean dumping) obtained in Alberni Inlet Econotech Services Ltd., New Westminster, B.C.	6,202

PUBLICATIONS

Institute of Ocean Sciences, Patricia Bay, 1976 Annual Report

PACIFIC MARINE SCIENCE REPORTS

PMSR 77-1

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 74, 18 June-9 August 1976.

PMSR 77-2

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 75, 30 July-16 September 1976.

PMSR 77-3

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 76, 10 September-27 October 1976.

PMSR 77-4

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 77, 22 October-8 December 1976.

PMSR 77-5

Cretney, W.J., W.K. Johnson, C.S. Wong — Trace analysis of oil in sea water by fluorescence spectroscopy.

PMSR 77-6

Macdonald, R.W., C.W. Wong — The interaction of chlorine and seawater.

PMSR 77-7

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 78, 3 December 1976 - 13 January 1977.

PMSR 77-8

Bell, W.H. — The use of extruded plastic fairing for a subsurface mooring.

PMSR 77-9

MacNeill, Margaret — A study of anomalous salinity and oxygen values in the deep water at Ocean Station P from 1960-1976.

PMSR 77-10

Foreman, M.G.G. — Manual for tidal heights analysis and prediction.

PMSR 77-11

Henry, R.F., M.G.G.Foreman — Numerical model studies of semi-diurnal tides in the Southern Beaufort Sea.

PMSR 77-12

Bell, W.H. — Static analysis of single-point moorings.

PMSR 77-13

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 79, 7 January-17 February 1977.

PMSR 77-14

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 80, 11 February-31 March 1977.

PMSR 77-15

Oliver, B.M., J.F.R.Gower — Airborne measurements of horizontal wind.

PMSR 77-16

Bell, W.H. — An In Situ drag coefficient determination for an Aanderaa thermistor chain.

PMSR 77-17

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50 N,145 W) volume 81, 25 March-12 May 1977.

PMSR 77-18

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 82, 6 May-23 June 1977.

PMSR 77-19

Mortimer, A., R. Schoenrank — A loran-C calibration, the west Canadian chain latticing and guidance systems for inshore operations.

PMSR 77-20

Frozen Sea Research Group — Oceanographic data Crozier and Pullen Straits, N.W.T. March-April 1977.

PMSR 77-21

Webster, I., D.M. Farmer	Analysis of lighthouse station temperature and salinity data - Phase II.

PMSR 77-22

Macdonald, R.W., C.S.Wong	The distribution of mercury in Howe Sound sediments.

PMSR 77-23

Frozen Sea Research Group	Oceanographic data report d'Iberville Fiord Ellesmere Island, N.W.T. March, 1977.

PMSR 77-24

Seakem Oceanography Ltd.	Oceanographic observations at Ocean Station P (50°N,145°W) volume 83, 17 June-3 August 1977.

CONTRACTOR REPORT SERIES
(Started 1977)

CRS 77-1

CTF Systems Inc.	Final report of a feasibility study on an underwater current meter platform.

CRS 77-2

Ward, John G., C.Eric Tull	Scientific studies to be conducted in response to an oil spill in the Beaufort Sea.

CRS 77-3

Webster, Ian	A physical oceanographic study of Haro Strait: a data summary and preliminary analysis.

CRS 77-4

Marko, J.R.	A satellite-based study of sea ice dynamics in the central Canadian Arctic Archipelago.

CRS 77-5

Associated Engineering Services Ltd.	Analysis of lighthouse oceanographic data - Phase III.

CRS 77-6

Gavin, A.M., V.I.Macdonald, Beak Consultants Ltd.	Annotated bibliography of the polychaeta of the Pacific Northwest.

DATA RECORD OF CURRENT OBSERVATIONS

Huggett, W.S., J.F. Bath, A. Douglas	Data record of current observations volume XV, Juan de Fuca Strait 1973.
Huggett, W.S., M.J.Woodward, A.N. Douglas	Data record of current observations volume XVI, Beaufort Sea 1974 to 1976.

INSTITUTE OF OCEAN SCIENCES NOTES
(Started 1977)

IOS Note - 1

Wong, C.S., J.A.J.Thompson, R.W. Macdonald	Chemical studies on mercury in Howe Sound and heavy metals at Point Grey Dump site, 1976-77.

IOS Note - 2

Lee, A.Y.P. (Editor)	Physical limnology of Babine Lake data summary 1972-1974, Part 1.

IOS Note - 2

Lee, A.Y.P. (Editor)	Physical limnology of Babine Lake data summary 1972-1974, Part 2.

IOS Note - 3

Walker, E.R.	Aspects of oceanography in the archipelago.

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Brinkhurst, R.O., 1977. Heterospecific groups. Bioscience, Nov., p.713.

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PERMANENT STAFF 1977

DIRECTOR GENERAL

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

ASSISTANT TO DIRECTOR GENERAL

Cornford, A.B.; B.Sc. (McMaster), Ph.D. (Brit.Col.)

MANAGEMENT SERVICES DIVISION

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Aanhout, D.L.v.
*Aavik, J.F.
Clarke, B.E.
Coldwell, J.H.
Cotter, M.L.
Craton, M.I.K.
Crouch, R.W.
Curtis, J.N.
Deane, G.J.
Doyle, D.A.
Drysdale, A.E.
Firth, C.
*Foote, S.B.
*Galibois, S.
Hall, E.J.
*Hogg, W. (deceased)
*Jensen, S.M.
Jones, K.M.G.
Kwiatkowski, B.S.
Lapp, B.I.; B.A. (Victoria)
Lohrmann, B.A.; B.Sc., M.Sc. (Guelph)
McKenzie, S.D.
*Martyn, B.T.
Miles, M.L.
Parsons, J.E.
Peirson, E.
Powers, M.A.
Reinstein, H.G.
Sabourin, J.T.
Smith, G.R.; B.A.Sc.(ME) (Brit.Col.), P.Eng.
Smith, R.M.
Thomas, C.D.
Thomson, L.S.C.; B.A. (Saskatchewan), B.L.S. (Brit.Col.)
van Dusen, T.S.
Wakefield, L.M.

*Left during 1977

COMPUTING SERVICES

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.)
Page, J.S.; B.Sc. (Brit.Col.)
Richards, P.J.; B.Sc. (Brit.Col.)
Smith, D.B.: B.Sc. (Victoria)
Teng, K.; B.A.Sc., M.A. (Brit.Col.)
Woollard, A.L.; B.Sc. (Victoria)
Woodward, M.E.; B.Sc. (Victoria) M.Sc. (Toronto)

HYDROGRAPHIC DIVISION

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Bell, R.D.
*Bennett, K.M.
Brown, R.E.
Browning, P.C.
Carracedo, C.
Chan, G.L.
Chivas, J.W.; Master, F.G.
Clark, D.J.
Coldham, F.A.
Cooke, R.A.
*Coulter, E.M.
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.
Dobson, D.C.
Dorosh, L.W.
Earl, E.L.P.
Eaton, G.H.; Dip.BCIT
Farmer, M.
Fisher, D.L.
Galloway, J.L.; B.A.Sc. (EE), M.A.Sc.(EE) (Brit.Col.),P.Eng.
Gregson, D.J.; Dip.BCIT
Harris, W.J.
Hermiston, F.V.
Hinds, E.W.; Dip.BCIT
Hohl, H.E.
Holman, K.R.
Huggett, W.S.; Master, F.G.
Johnson, B.A.; Dip.BCIT
Ma, A.C.; B.Sc. (Victoria)
Manley, A.B.; Dip.BCIT
May, R.I.D.; Dip.BCIT
Milner, P.R.; Dip.BCIT
Moody, A.E.
Mortimer, A.R.; Master, F.G.
Morton, P.A.; A.O.C.A.
Muse, R.A.; Trade Cert.CAF
*Nast, C.J.
Nielson, G.C.
O'Connor, A.D.; Master, H.T.(U.K.), 350 T
Osbourne, 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
*Prussner, L.E.; Dip.BCIT
Rapatz, W.J.; B.Sc.(Victoria)
Raymond, A.R.; Dip.(Algonquin College)
Richardson, G.E.
Ross, A.D.
Ryan, C.F.; Dip.RRE (England)
Said, N.A.
Sandilands, R.W.; Lt.RN (Retd.)
Sargent, E.D.; Dip.BCIT
Shoenrank, R.U.; B.Sc. (Victoria)
Smedley, A.J.; Lcdr.RCN (Ret'd.)
Smithers, F.R.
Soutar, T.J.; Dip.BCIT
Steeples, J.; Cert. Mech. Eng. (Edinburgh)
Stephenson, F.E.; B.Sc. (Victoria)
Tamasi, C.R.; Dip.BCIT

*Left during 1977

*Johnson, R.W.
Josephson, K.G.
Korhonen, R.K.
Kynoch, B.D.
Larkin, J.G.; B.Sc.(P.E.I.)
Loschiavo, R.; Dip.BCIT
Lusk, B.M.; 350 T
Lyon, A.G.
Lyons, W.J.L.; C.C. (Ont. Inst. Cartographers)
Wigen, S.O.; B.A.Sc. (Brit.Col.), P.Eng.
Wills, R.; Master, F.G.
Wood, D.J.; Dip.BCIT
Taylor, M.S.
Taylor, R.G.
Taylor, W.R.; Dip.RCC
Thompson, L.G.
Vosburgh, J.A.; Dip.(BCIT)
Wanamaker, J.G.; Dip.BCIT
Ward, M.M.; Dip.(BCIT)
Watt, B.M.
Watt, J.W.; B.A.Sc.(EE) (Brit.Col.), P.Eng.
Woods, M.V.; Dip.BCIT
Woodward, M.J.; B.Sc. (Victoria, M.Sc. (Toronto)

OCEAN PHYSICS DIVISION

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Bigham, R.H.
Chase, G.W.; Dip.BCIT
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Farmer, D.M.; B.Com., M.Sc.(McGill), Ph.D. (Brit.Col.)
Freeland, H.J.
Gargett, A.E.; B.Sc. (Manitoba), Ph.D. (Brit.Col.)
Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
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Herlinveaux, R.H.
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McNeill, J.M.
Meikle, J.H.
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Richards, D.L.
Sieberg, D.G.; Dip.VVI
Smiley, B.D.; B.Sc., M.Sc. (Alberta)
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Wallace, J.S.

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Denman, K.L.; B.Sc. (Calgary), Ph.D. (Brit. Col.)

OCEAN CHEMISTRY DIVISION

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

Bellegay, R.D.; Dip.NAIT, Ass.Deg. in Oceanography (Shoreline Community College, Seattle)
Cretney, W.J.; B.Sc., Ph.D. (Brit.Col.)
*Jackson, C.M.; B.Sc. (Victoria)
Johnson, W.K.; Dip.BCIT
Macdonald, D.M.; B.A.Sc. (Brit.Col.)
Macdonald, R.W.; B.Sc., Ph.D. (Dalhousie)
McLaughlin, F.; B.Sc. (Victoria)
Munro, P.; B.Sc. (Queen's)
Paton, D.; B.Sc. (Brit.Col.)
Thompson, J.A.J.; B.Sc. (McMaster), Ph.D. (Alberta)

SHIP DIVISION

Geldart, E.N.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Regional Marine Superintendent
Green, F.S.	Master Mariner; Assistant Marine Superintendent (Deck)
*Marr, D.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Assistant Marine Superintendent (Engineering)
Parkinson, R.	Engineer 1st Class Combined; Chief Engineer
Keene, R.W.	Master, F.G. (X); Relief Master
Henderson, J.D.	Engineer 2nd Class Steam; Depot Supervisor
Chan, C.C.	Engineer 1st Class Motor; Relief Engineer

CSS PARIZEAU

Chamberlain, A.G.	Master, F.G.; Master
Fisher, E.G.	Master, F.G.; 1st Officer
Christie, J.N.	Radio Certificate; W/O
Clarke, L.E.	Supply Officer
Kyle, R.G.	Engineer 2nd Class Motor; Senior Engineer
Orr-Hood, J.	Engineer 4th Class Motor; 2nd Engineer

*Left during 1977

CSS WM.J.STEWART

Sjoholm, K.J.	Master, F.G.; Master
Easson, R.J.	Master, F.G.; 1st Officer
Palmer, S.	Supply Officer
Gibson, R.B.	Engineer 3rd Class Steam; Senior Engineer
Conway, A.	Engineer 4th Class Combined; 2nd Engineer

CSS VECTOR

Marston, J.C.	Master, F.G.; Master
Bishop, S.O.	Mate H.T.; 1st Officer
Purdon, D.	Mate, H.T.; 2nd Officer
Peet, J.	Engineer 3rd Class Motor; Chief Enginer
Pearson, R.	Engineer 3rd Class Motor; 1st Engineer
Knoblauch, I.	Engineer 4th Class Motor; 2nd Engineer

CSS RICHARDSON

Wheeler, M.G.	Master, 350 T; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

MV RADIUM EXPRESS

O'Sullivan, J.	Master
Butler, W.	Chief Engineer

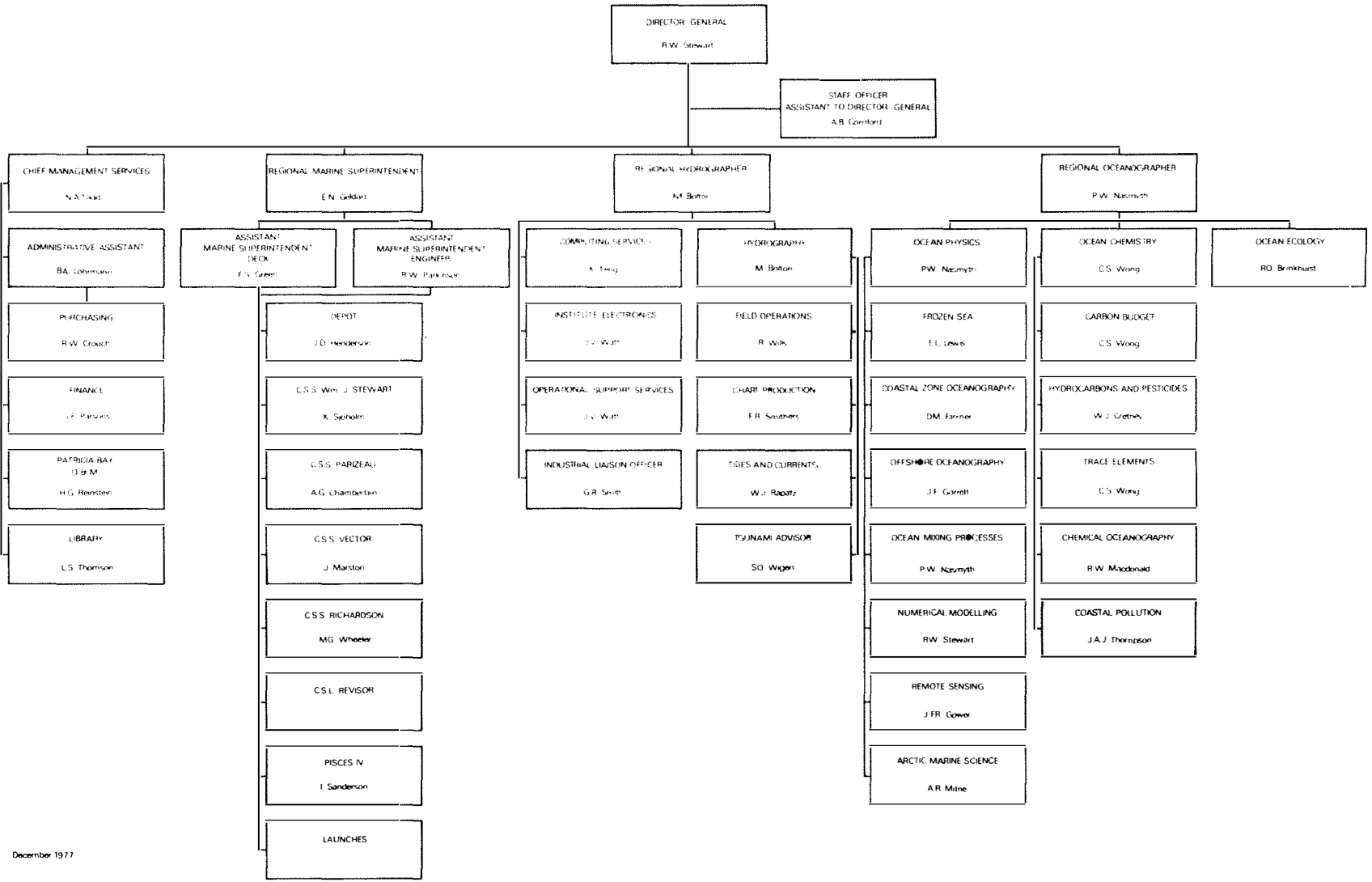
MV PANDORA II (Charter)

Jones, R.	Master
Tuck, C.	Chief Engineer

PISCES IV

*Meek, G.R.	Operations Officer
Sanderson, I.	Chief Pilot
Chambers, F.	Pilot
Taylor, R.H.	Pilot
Jacobson, R.	Pilot
Gaudreault, J.	Pilot
Grant, D.	Pilot

*Left during 1977



December 1977