INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT - 1978

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Sidney, B.C.

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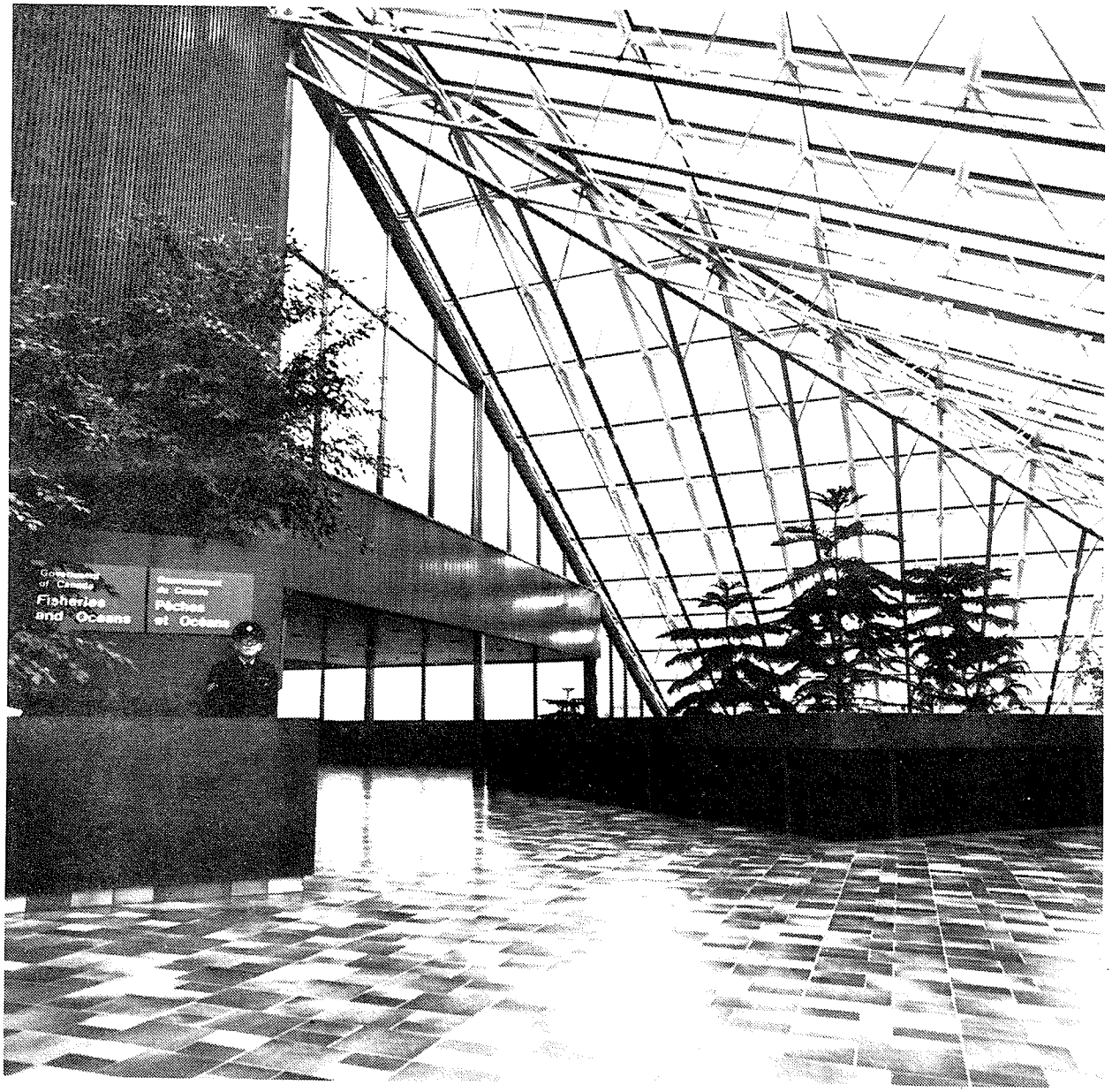


Sidney, B.C.

March, 1979

CONTENTS

	Page
Director-General's Office	3
Hydrographic Division	5
Field Hydrography Section - 27	7
Chart Construction Section - 31	11
Tidal and Current Survey Section - 12	15
Tsunami Advisor	17
Computing Services Section - 12	17
Engineering Services - 11	21
Mechanical Engineering	23
Industrial Liaison and Contract Activity	24
Oceanographic Divisions	25
Frozen Sea Research Group - 10 2 3 13	27
Ocean Mixing Section 3	31
Coastal Zone Oceanography - 11	32
Offshore Oceanography Section - 9	39
Numerical Modelling - 6	46
Remote Sensing Section - 2	48
Arctic Marine Science - 3	51
Ocean Chemistry Division - 14	54
Ocean Ecology Laboratory - 7	63
Ship Division	66
Management Services Division	69
Library	71
Task Force, Committee and Similar Activities	72
Service Related Contracts	78
Publications	83
Permanent Staff	90
Organization Chart	95

DIRECTOR-GENERAL'S OFFICE

R.W. Stewart

T. Van Dusen - Secretary A.B. Cornford

The end of 1978 sees members of the Institute of Ocean Sciences at last settled into their fine new quarters. It also sees them more and more working as an Institute, as the rather pachydermal shells, appropriate to the separate existence that groups formerly had, become replaced by more permeable membranes appropriate to our new physical togetherness. The increased effectiveness of our work arising from this integration was the rationale behind the expenditure of $20,000,000 of the taxpayer's money on the construction of the facility. As dreams have become reality, one senses that the faith, energy, and initiative of the many people who made this Institute possible, are being justified.

The fiscal restraints of the times have made our work more difficult, and leave everyone with a very cramped feeling. This feeling is not helped by a general realization that things are likely to get worse before they get better. Nevertheless, as this report indicates, we retain a substantial capability, and have been applying this capability to problems we perceive as being important. The fact that this report is replete with references to new instruments and new techniques shows that while our diet has become a spartan one, it has not yet reached the stage of starvation. Our long-standing efforts to work with the private sector through the Make-or-Buy policy have paid off, at times almost spectacularly, in the way in which private companies are conducting work of direct interest to us, but largely funded by non-Institute funds through the unsolicited proposal route.

It is interesting to note that despite the general sense of disillusion with the national and provincial economy, chart sales this year bounded upward to an unprecedented figure, following several years of stagnation. Perhaps a portent of a more prosperous future?

Again this year, *Pandora II* was able to get into the Arctic and achieve a substantial surveying job. Nevertheless, one continues to feel there must be a better way than having to fight the waters off the north coast of Alaska twice every year and give up the whole summer of a major ship in order to get in a couple of months of survey.

We were even able to maintain some presence on the international oceanographic scene. At year-end *Parizeau* was on her way towards her equatorial station, to take part in the great Global Weather Experiment (First GARP Global Experiment). The year-end also saw a remarkable cooperative effort in which a side-scan-sonar team put together by Hydrographic Division and Ship Division, together with an Armed Forces diving team, were able to recover an Oceanographic Division instrument from the bottom of English Bay -- just in time to put it aboard *Parizeau* for use on the equator. That we are able to respond promptly and effectively to unforeseen circumstances leaves a gratifying feeling of vigorous life.

Prime Minister, Pierre Trudeau with Frank Chambers, Pisces IV pilot, inspecting the submersible while it was on display at the Canadian National Exhibition, 1978.

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

D. van Aanhout - Secretary

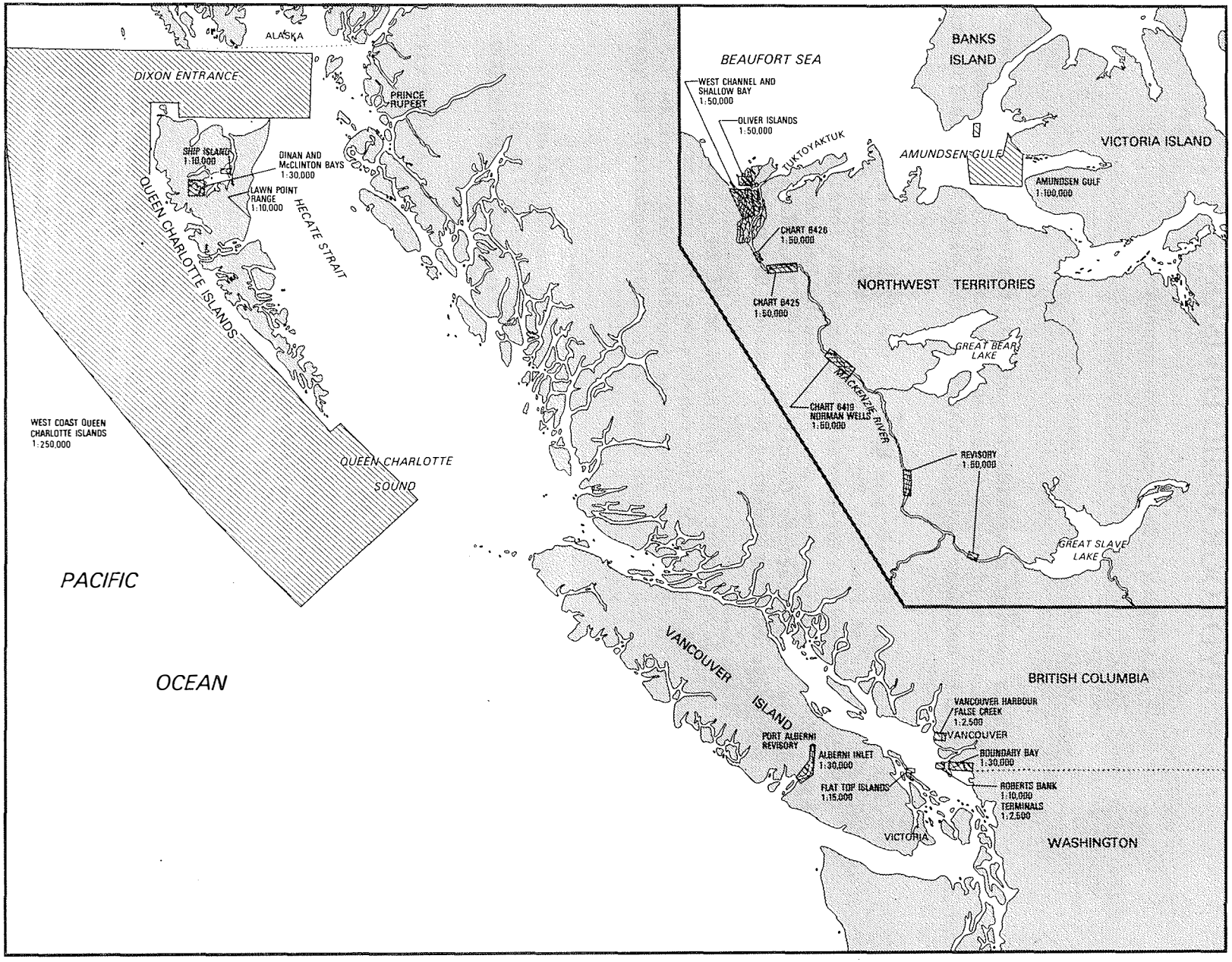
This was a year of consolidation and adaptation to the excellent facilities at the Institute of Ocean Sciences. As was anticipated, some minor adjustments were necessary but, in the main, the staff and the Institute fitted remarkably well.

A highlight of the year was hosting the 17th Annual Canadian Hydrographic Conference at Patricia Bay in April. Over three hundred delegates attended, including representatives from eight foreign hydrographic organizations. The wind-up luncheon was addressed by Rear Admiral Steve Ritchie, President of the Directing Committee of the International Hydrographic Organization, who spoke on "The Widening Horizons of Hydrography".

The design, development and installation of an extendible transducer aboard M.V. *Pandora II* under severe time constraints was a major factor in the successful completion of arctic surveys in Amundsen Gulf. Multi-disciplinary surveys off the B.C. west coast were again conducted, as were the ongoing surveys on the Mackenzie River and Delta.

The establishment of a Technical Records Unit in Chart Construction, in which all hydrographic documents are consolidated has considerably advanced the service for all users. The demand for charts continues at a high level and this year, for the first time, over 200,000 charts were distributed.

Computing Services continued to upgrade systems associated with the UNIVAC 1106, consequently the workload continues to increase with outside (non-OAS) users representing about 18% of the total volume.



Field survey operations, 1978

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
A.R. Raymond
G.E. Richardson
E.D. Sargent
R.U. Schoenrank
C.R. Tamasi
+W.P. Van Duin
J.A. Vosburgh
M.M. Ward
D.J. Wood
M.V. Woods

*Left during 1978
+Joined during 1978

R.W. Sandilands - Head, Sailing Directions
*J.W. Chivas
+A. Smith
L.M. Wakefield

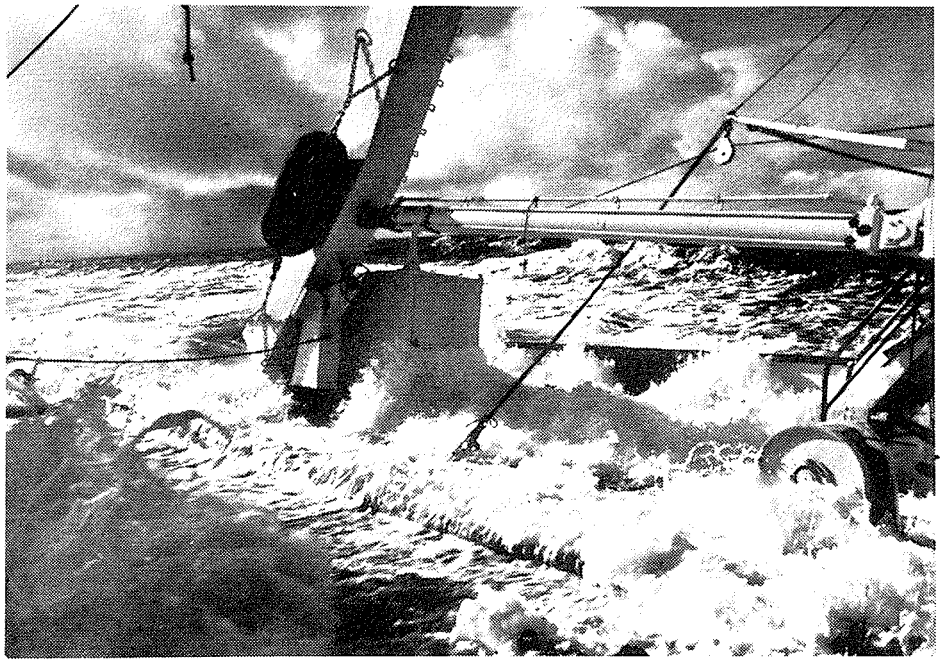
J.B. Larkin - Head, Hydrographic Development
A.J. D'Aoust
**K.L. Czotter
**M.L. Preece

**Rotational Staff in Hydrographic Development.

The main hydrographic work on the B.C. Coast in 1978 was carried out by a large party with Mr. B.M. Lusk in charge. Surveys of Vancouver Harbour (False Creek), Roberts Bank Superport, Tsawwassen, Boundary Bay, Alberni Inlet and the Flat Top Islands area were completed. All but Vancouver and vicinity had been last surveyed in the 1930's well before the use of echo sounders. Offshore multi-disciplinary surveys were carried out by C.S.S. *Parizeau* off the west coast of the Queen Charlotte Islands from the Scott Islands north to the Alaska border during the period 4 July to 14 August. For the first time in this region a new Marconi Sat. Nav. and Austron Loran-C were employed for precise positioning, eliminating the need to establish shore installations, apart from electronic positioning sites used for calibration purposes. The prime purpose for the cruise was the collection of gravity data but complete magnetic and seismic coverage was conducted as well as standard bathymetry. Considerable effort has been made by the Hydrographic Service off the West Coast during the years 1973, 1975, 1976 and 1978 contributing toward the joint D.F.O./E.M.R. natural resource charting

program. A small area in Hecate Strait is all that remains to be covered in the nearshore zone.

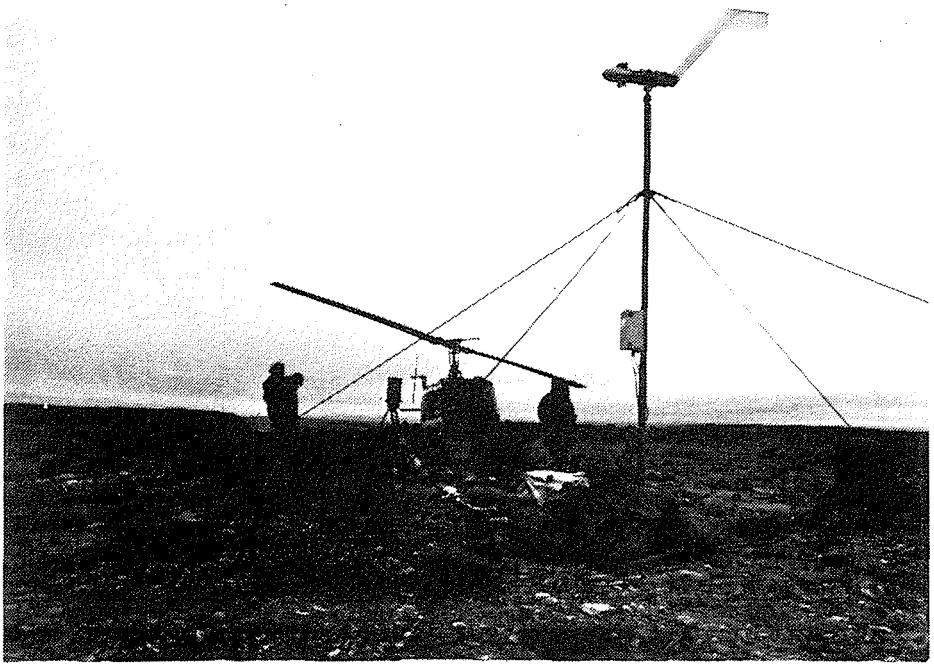
C.S.S. *Richardson* was employed on hydrographic surveys somewhat greater in extent than has been usual for her in recent years. A small party with Mr. J. Vosburgh in charge completed a number of outstanding projects including new surveys of Sabine Channel and False Bay, and in the Queen Charlotte Islands, Lawn Pt. range, and the vicinity of Ship Island in Masset Inlet. Work in Masset Inlet also included surveys of Dinan Bay and McClinton Bay which were previously unsurveyed. At season's end additional revisory work was carried out in Barkley Sound, Port Alberni (Somass River) and the Port Moody, Indian Arm area of Vancouver Harbour. Consistent with the practice in recent years, major revisory surveys in southern areas were carried out by contract.



Stern of Pandora II awash during surveys in Amundsen Gulf

Even though plagued by bad weather and rough seas, Mr. A.D. O'Connor's party on *Pandora II* had another successful season in the Western Arctic. Multi-disciplinary surveys of the main area of Amundsen Gulf were completed since ice conditions prevented sounding in the primary area in eastern Beaufort Sea. In the course of these operations a hydrographer was detached to work on a levelling project for the Geodetic Survey of Canada in the Mackenzie Delta. *Pandora II* served adequately as a major survey ship. Her sounding capability, previously found wanting, has been firmly established with the installation of an extendible transducer. It performed well under all conditions encountered and the success of the cruise can be directly attributed to it. The portable hydrographic acquisition system (PHAS) performed well this season and Pagecom F.M. radio pagers were

used to advantage in conjunction with it. The wind generator was again used to keep shore station batteries charged all season, and for the first time in this area, expendable sound velocimeters (X.S.V.) manufactured by Sippican Corporation, were used to determine velocity corrections to our echo sounders.



R.P.S. beacon and wind generator installed on Victoria Island

The charter vessel *Radium Express*, with Mr. J.V. Crowley in charge, continued the Athabasca-Mackenzie Waterway survey program. Surveys were completed of shoal areas at km 283, and at km 492 and 562 where sand bars had encroached on established ranges. Sounding was also completed near Norman Wells for chart 6419. Surveys were carried out in Shallow Bay and its approach channels, and the survey of West Channel was completed. The annual revisory survey of the Mackenzie River was also completed, as was the photographic surveillance of artificial islands in the Beaufort Sea.

Mr. A.R. Mortimer continued his studies of the Canadian West Coast Loran-C chain. This included a cruise on C.S.S. *Parizeau* in November to make cycle identification tests at the approaches to Juan de Fuca Strait, where signal reception problems exist. Adequate data was collected to define the lattice shift for charts of Dixon Entrance/Hecate Strait and Queen Charlotte Sound. Development work continued on a Sat Nav, Loran-C based integrated navigation system. Dr. Dave Wells from Bedford Institute of Oceanography worked throughout the Juan de Fuca cruise developing programs for the integrated system and created a system capable of positioning *Parizeau* on the forthcoming First Garp Global Experiment cruise.

Sailing Directions

The second edition of B.C. Small Craft Guide, Volume II, Boundary Bay to Cortes Island was published in April. The coverage of this volume has been extended beyond that of the first edition and now includes Prideaux Haven and the designated marine park area of Desolation Sound, an increasingly popular area for recreational boaters. The seventh edition of B.C. Coast Sailing Directions, North Portion, Volume II was published in July and new editions of B.C. Sailing Directions, South Portion, Volume I and B.C. Small Craft Guide, Volume I are under preparation.

The Sailing Directions for Kootenay Lake and River which are printed to accompany chart 3050 were revised and passed to the Chart Compilation section which has the chart in production. The section also participated in a contract for revisory surveys and obtained revision material on the southern B.C. waters.

Hydrographic Development

A. D'Aoust moved to Ottawa in early summer to work full time on the Aerial Hydrography Project at Canada Centre for Remote Sensing. As a result of an unsolicited proposal, a review of the project was made, and specifications for a contract have been prepared. It is anticipated that the contract will be let early in 1979, and is scheduled for completion in eighteen months.

Hydrographers K. Czotter and M. Preece joined the section for their rotational assignment, and their major effort was directed to computer program development. Field sheet drawing programs were modified extensively to take advantage of some features of the Kongsberg flatbed system as well as to improve the visual quality of the field sheet. The section assisted hydrographers in preparing field sheets on the flatbed plotter before the survey season and final field plotting and title application in the fall. K. Czotter took several "breaks" during the year. He joined East Coast hydrographers in August for the Eastern Arctic Survey on board CCGS *John A MacDonald*, and attended the Hydrography II course in Ottawa for six weeks late in the fall.

Survey program packages were written for, and implemented on the HP67/97 hand held programmable calculators, the HP 9825 desktop calculator, and the DEC PDP-11 computer. Assistance was provided in assembling and checking the region's horizontal control data in preparation for inclusion in a geographic data bank.

J. Larkin and A. D'Aoust attended a Coastal Mapping Symposium in Rockville, Maryland in mid-August, and J. Larkin also attended the Fifth Canadian Symposium on Remote Sensing in Victoria during the last week of August.

CHART CONSTRUCTION SECTION

*F. R. Smithers - Regional Chart Superintendent
W. S. Crowther - A/Regional Chart Superintendent

R. Bell - Supervisor New Chart Production
P. Browning
G. Chan
*D. Clark - Supervisor Chart Correction
W. S. Crowther - Production Chief
D. Dobson
E. Earl
M. Farmer
D. Fisher - Supervisor Chart Sales
+J. Gould
+D. Harrison
M. Hohl
K. Holman - Supervisor Chart Revision
+S. Huggett
K. Josephson
R. Korhonen
D. Kynoch
A. Lyon
*W. Lyons
P. Morton
G. Neilson
R. Parker
M. Patton
A. Philp
L. Pickell
R. Pierce
A. Ross
N. Said
+J. St. Gelais
R. Taylor
*M. Taylor
L. Thompson
B. Watt
+G. Whincup

+Joined during 1978
*Left during 1978

1978 was a year of shake-down and adjustment for the Chart Production staff. New equipment, new surroundings and new programs helped to create an invigorating work environment.

The main efforts were directed to establishing a Technical Records Unit, maintaining chart stocks, and continuing the metrication program in accordance with national priorities.

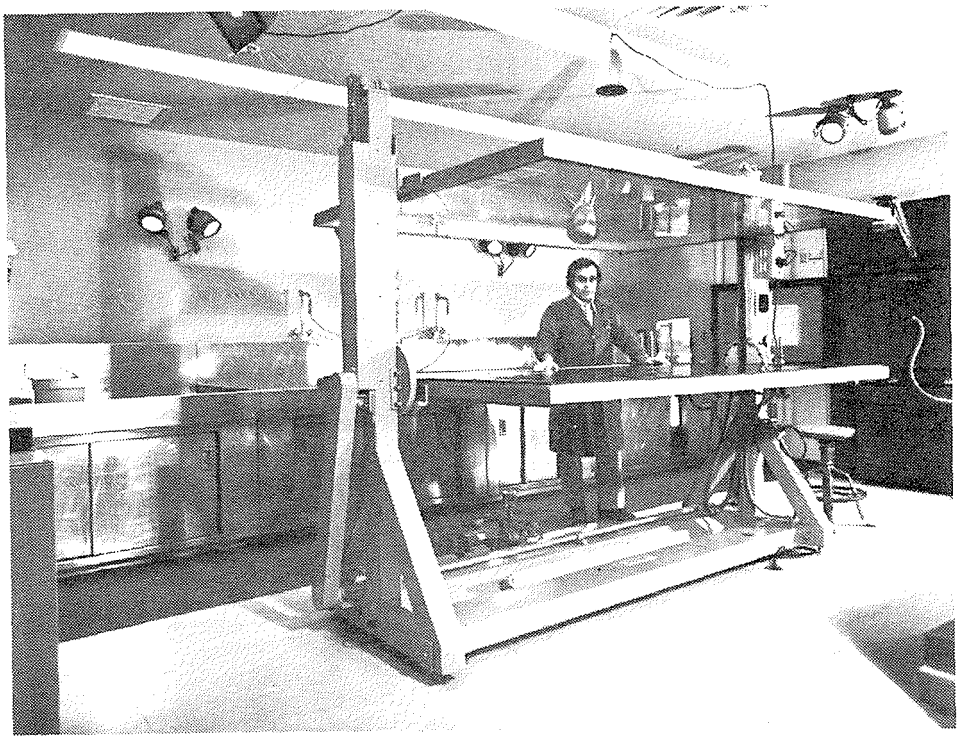
Establishing the Technical Records Unit proved to be a larger than expected task. Nevertheless, the consolidation of all Field Sheets, Field Notes, Files and Chart Reproduction material in one location, under one responsible person provides efficient service to all users. This consolidation was necessary to maximize the control and utilization of all official records and documents.

Maintaining chart stocks was not a simple task in 1978. This was our largest volume year ever. The total number of charts distributed exceeded 210,000, and hand amendments reached 1,765,000. In addition, seventy dealerships were inspected, one Class 'A' dealership in this Region became a reality, and nineteen new dealerships were established.

Emphasis on metrication continued in new Chart Production. In all, eight new charts of the bilingual-metric format were printed and a total of fifty-six new editions were printed of which eighteen were bilingual. Stock depletion necessitated nineteen reprints. To minimize costs and to expedite amendments to existing stock, three overprintings were undertaken. Twelve chart patches were prepared and printed, sixty Notices to Mariners were issued and ten Notices to Shipping were also processed.

Technical Records Unit

Graphic arts services continued to be provided on an as-available basis as continuing reprographic services for the Institute as a whole. The installation of the large vacuum frame in the Photo Mechanical Unit has greatly enhanced the quality of contact reproduction.



New Douthitt Vacuum Frame in Photo-Mechanical Unit

The Cartography 1 Training Course held at Ottawa was successfully completed by four cartographic staff in 1978. Four cartographic staff attended the Canadian Cartographic Association Conference held in Vancouver in June. The last cartographer to move from H.Q. as a result of decentralization arrived in Pacific Region this summer.

Conferences have become a regular occurrence at the Institute of Ocean Sciences. As part of the ongoing efforts to make available information regarding the work of the Institute, personnel from Chart Production often provide graphic arts services. Of particular note, the Map Librarians on a tour recently showed a keen interest in the Canadian Hydrographic Service, its history, as well as its production procedures and techniques.

Chart Production, assisted by Sailing Directions, hosted a large gathering of Power Squadron members in April. A total of 125 were treated to a film, lectures on navigation, advice on MAREP reporting and a lengthy tour and explanation of hydrographic chart production procedures and techniques. Power Squadrons submitted 430 MAREP reports affecting West Coast charts during 1978.

The Pacific Region Chart Production Section now has the capability of doing its own photohead plotting of mathematically generated graphics, and has integrated a GOMADS graphics editing and digitizing system into the chart production processes. The systems were brought on line by the Computer Services section.

Production & Distribution Statistics, 1978

New Charts published	8
New Editions published	56
Reprints published	19
Overprinting of existing chart stocks	3
Notices to Mariners issued	60
Notices to Shipping processed	10
Chart patches printed	12
Chart corrections (hand amendments)	1,765,000
Total charts distributed	210,000
Dealerships inspected	70
New Dealerships established	19
Dealerships withdrawn	0
MAREPS processed	430

TIDAL AND CURRENT SURVEY SECTION

W. J. Rapatz - Acting Regional Tidal Superintendent

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

*Left during 1978
+Joined during 1978

The major tidal and current field survey in Johnstone Strait and Queen Charlotte Strait was completed early in 1978. As a result of this survey one reference current station and ten secondary stations have been added to Volume 6 (1980) Tide and Current Tables. The current observations from this survey are being prepared for publication in 4 volumes.

Work continued on an atlas of surface currents in Juan de Fuca Strait and the Gulf Islands. Surface currents in Juan de Fuca Strait were further investigated by carrying out several launch and air surveys, with assistance from the Remote Sensing Group. These surface currents are much more complex than was originally thought and further measurements must be carried out before the current atlas can be completed.

In the Fraser River, detailed measurements were made of salinities, temperatures and currents in and near the toe of the salinity wedge. The upstream limit of the salinity wedge was determined for a variety of discharges and tidal ranges.

In co-operation with the Water Quality Branch of Inland Waters, 24-hour time series of currents, salinities and temperatures were carried out at a number of stations between Steveston and New Westminster. Current measurements and salinity observations were also made in the North Arm and Canoe Pass area. A tide gauge was operated at the mouth of the North Arm for 12 months to provide the numerical model with a more accurate boundary condition. This computer model of tide heights in the Fraser River continued to be used by various government agencies and by private industry.

To examine the predictions of a previously developed oilspill computer program, a number of 24-hour surface flow measurements were made in Juan de Fuca Strait. These measurements were made from shipboard and by aerial reconnaissance in co-operation with the Remote Sensing Group. New equipment to track electronic oilspill markers was successfully tested.

A numerical model of Burrard Inlet was developed. Field measurements were made at the entrance to Burrard Inlet but more field measurements, particularly in winter months, are needed to properly calibrate the model. Useful boundary conditions for the model have yet to be determined.

Research on long period tides was conducted. The Solar annual (Sa.) and Solar semi-annual (Ssa.) tides for ports in Canadian waters were analyzed and the amplitudes and phase angles obtained were submitted for inclusion in the prediction process for Canadian Tide Tables. Research was also carried out into monthly and fortnightly tides.

A tide and current survey of Dodd Narrows and Porlier, Active and Gabriola Passes was conducted to improve current predictions for these locations. Tide gauges were deployed at both ends of each pass to determine the hydraulic head. Several months of current observations were carried out to construct and calibrate an empirical model showing the relationship between current and hydraulic head. All field work, with the exception of final recovery of the tide gauges (January 1979), was completed. Analysis of the data is still in progress.

The tsunami warning system gauge at Langara Island was destroyed in October 1977 by a large wave and was not fully operational again until almost a month later.

The records obtained at 24 permanent tidal stations and 6 long-term temporary stations operating on the Pacific Coast and in the Western Arctic were routinely processed, digitized and the data sent to the Marine Environmental Data Service in Ottawa. The new data processing system is now fully operational. This has resulted in reduced processing time and a higher quality of processed data. Work was started on further improving the data processing system by converting it from a magnetic tape to a disc-oriented data storage system.

Aanderaa gauges installed at Tuktoyaktuk, Cape Parry and Cambridge Bay in August 1977 were recovered. The data collected by these instruments have been processed and are now being analyzed. A detailed comparison will be made between these data and the data collected by the permanent water level gauge operated at these locations. The results of this investigation will be distributed as a report in 1979.

TSUNAMI ADVISER

S.O. Wigen

Present studies have shown that tsunamis have occurred fairly frequently on the Canadian west coast, and more than 20 have been recorded by the tide gauge at Tofino. These records are being studied in order to determine the frequency with which damaging tsunamis may be expected, and to prepare guidelines on advisable precautionary measures. Particular attention is being given to the Port Alberni area, which sustained considerable damage in 1964.

A federal-provincial working group has been formed to bring about improvements in tsunami warning procedures in British Columbia including the development of public education programs on the hazards of tsunamis and appropriate responses when one is occurring. A Canadian working group has also been formed to develop a joint Canadian-U.S. report on use of satellites in the International Tsunami Warning System. This report was requested by the International Co-ordination Group for the Tsunami Warning System in the Pacific and is in final stages of preparation.

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns
D.B. Smith
J.W. Butcher
A.N. Douglas - Tides and Currents
M.G. Foreman - Numerical Modelling
*S.R. Oraas
J.S. Page - Ocean Chemistry
P.J. Richards - Numerical Modelling
A.L. Woollard - Tides and Currents
+M.E. Woodward - Frozen Sea Research Group
*A. Wharton - Frozen Sea Research Group
+E. Wong - Offshore Oceanography
*P. Lacroix - Offshore Oceanography
+S.J. Szalai - Management Services
*R.G. Hlady - Management Services
*G. Silver - Hydrography

+Left in 1978
*Joined in 1978

Univac 1106 Computer System

1978 was primarily a year of consolidation for the Institute's Univac 1106 Computer System, featuring minimal hardware changes but considerable activity in the area of software upgrading and implementation.

The long-awaited motor/generator set (to regulate the power supply to the computer system) was finally installed in April. This eliminates most of the short-term voltage fluctuations that had been causing system outages during its first 18 months of service. The improvement in "mean time between outages" and "% availability" during the summer is reflected in the following summary:

	Before M/G	After M/G
Mean time between computer outages	7 hr 20 min	13 hr
% availability	89%	92%

In May, demand terminal communications at the Institute were considerably improved with the installation of a Gandalf MINI-PACX port selector in the computer room and the replacement of several dial-up lines by dedicated building circuits to which local terminals are connected via Gandalf line drivers. In September, four, 300 bytes per second (bps) ports were replaced by 1200 bps ports, to provide faster communications for the many new CRT terminals that have been installed. At year's end there were 12 hard-wired terminals and 4 dial-up lines contending for 10 ports (4 at 1200 bps, 6 at 300 bps).

Due to low utilization, the Vancouver remote batch terminal was discontinued in August and the high-speed, dial-up port was terminated in September. Batch output for Vancouver users (Fisheries Management) is now being provided by a delivery service.

Operating system software, processors, and utility routines were upgraded throughout the year. New versions of ASCII Fortran, PL/1, ASCII Cobol, System 2000 (data-base management package), the Text Editor, Sort/Merge, etc. were implemented. New utilities for dumping files/tapes, break-pointing print files, and obtaining master file directing information were among several introduced during the year.

Several applications software packages were acquired late in the year to augment the computing system's offerings. These are:

- the IMSL (International Mathematical and Statistical Libraries) sub-routine library, to provide state-of-the-art mathematical and statistical routines;
- SPARSPAK (A Sparse Matrix Package), primarily for solving large systems of linear equations featuring a sparse matrix structure.
- FESTA (Fast and Easy System for Time-Series Analysis).

A Computing Services Information Bulletin was produced and distributed (in February and October) to users for the purpose of publishing timely information concerning the Univac system. At year's end, an Introductory Users' Guide, and a Users' Manual were nearing completion. These will supplement the Univac manuals and System News files, and will help fill a void in readable user documentation.

In the applications area, the Hydrographic Charts Inventory and Accounts Receivable System was converted from the Vancouver IBM Datacentre to the Institute's Univac 1106. Also, development of the computerized Library Book Catalogue continued during the summer, and some catalogue data were entered into the data-base. These projects were carried out by summer students working under the supervision of Computing Services Staff.

The workload on the Univac system continued to increase, with major users being Offshore Oceanography, Coastal Zone Oceanography, Contract Support Services and Numerical Modelling. The Pacific Geoscience Centre of E.M.R. also became a user in the fall. The value of average monthly usage during 1978 was:

OAS users	$32,439
Other users	5,706
Total (all users)	$38,145

This represents a 60% increase over 1977 levels.

Automated Cartography

During 1978, work continued on the development of computerized tools to assist Chart Construction. Four software packages were transferred from the Cyber 74 computer at the Ottawa office of the Canadian Hydrographic Service to the Institute's Univac 1106. These were the Full Graduated Border program, the Small Craft Border program, the Hyperbolic Lattice program and the Curve Fit program. These, combined with a utility program which converts Gerber plot format to Kongsberg plot format, gives this region the capability to produce its own borders and lattices.

Late in March, the Institute took delivery of the hardware required for a GOMADS interactive editing and digitizing system. The equipment includes a PDP11/34 mini-computer with 64K words of memory and hardware floating point, dual RK06 disc drives with 14M bytes capacity each, two 9-track magnetic tape drives, a Talos 36x48 inch digitizing table, and a Tektronix 4014 graphics terminal. The system runs under RSX-11M, a multi-user, multi-tasking real time operating system. The GOMADS interactive graphics editing program was transferred from the CHS in Ottawa and is now operational. It has been used in the production of the compartment chart borders for Fraser River charts 3488 and 3489, as well as for a preliminary version of field sheet 1219. The MOSAIC program was also transferred from the Cyber 74 computer in Ottawa to the PDP11 and is now fully operational. It was used in the production of preliminary field sheet 1219 to convert the projection from UTM to Mercator, to change the scale, and to perform roundings of the soundings.

The Kongsberg flatbed plotter was used by four groups this year. Field Hydrography used it for producing field sheets, using liquid ink on mylar. Chart Construction produced compartment chart borders and a small craft border on photographic film using the light head. Tides and Currents produced a large number of report-quality plots on photographic film using an HP2100 mini-computer system to produce the magtapes. The Geological Survey section of EMR used several paper plots of Loran-C lattices. The Kongsberg plotter is proving to be a reliable and versatile plotting system.

Mini-Computer and Micro-Processor Developments

The various mini-computer systems throughout the Institute are heavily used in applications suited to their versatility, portability and ability to interface with special equipment. Much of the activity involves equipment and programs which have been in use for some time. Some of the new activities are purely programming efforts; some involve exploiting newly acquired equipment.

Hardware acquisitions include a dual-plotter disk for Tides and Currents' HP2100S system, an HP2645 CRT terminal with cartridge drives for Computing, an HP 2648 graphics terminal with cartridge for Coastal Zone Oceanography's HP2112 system, and an HP2635 printing terminal for Offshore Oceanography's HP2100 shipboard computer. The RTE-II and RTE/M Real-Time operating system software was also purchased, although implementation is only in the early stages.

Significant developments include:

- A complex real-time acquisition system for Coastal Zone's acoustic current metre. The graphics terminal is used to display the current profile as the probe is lowered.
- A similar type of system with no graphics, but more printed output was completed for Offshore Oceanography's use on the HP2100.
- The development of drivers for the HP2645 and 2648 terminals has cut down drastically on the need for paper tape in developing software for non-disk systems.
- An HP-user-contributed cross-assembler for the Intel 8080 family of micro-processors was acquired and extensively re-coded, providing a convenient facility for micro-program development.

The past year saw the completion of two micro-processor-based data recording systems. Ocean Mixing's SCRIBE is a dual-processor system combining high speed and low power consumption. A spin-off of the above effort was Remote Sensing's SPECTRE, a compact system which is used for airborne water colour studies. Both these developments made extensive use of the Hewlett-Packard based Editor and Cross-Assembler. If, as planned, a programmer for erasable programmable read only memories (EPROMS) is developed for one of the minis, we may expect the use of micro-processors in special-purpose instruments to become increasingly common.

ENGINEERING SERVICES

J.V. Watt - Head

INSTITUTE ELECTRONICS

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

*Joined in 1978
**Transferred to Frozen Sea Research Group during 1978
***Transferred to Ocean Chemistry during 1978.

Institute Electronics provides electronics engineering and technical support for survey, research and ship operations in the Pacific Region. Both the Engineering Support Group and the Technical Support Group experienced a very active and successful year during 1978.

Engineering Support Group

The support to the Institute during the past year involved a considerable variety of design, prototype manufacture, testing and consulting activities. Some of the more prominent of these tasks were the completion of two micro-processor-based data acquisition systems, extensive design modifications to a current shear probe, a special purpose winch controller and an extendible echo sounder transducer on the M.V. *Pandora II*. The data acquisition systems SCRIBE (Ocean Mixing Section) and SPECTRE (Remote Sensing Section), provide the capability to record onto 9 track tape small scale ocean turbulence data aboard the *Pisces IV* and spectrometer data aboard small aircraft respectively.

Considerable engineering effort was expended in modifying a current shear probe developed by the Institute's Offshore Oceanography Section and in managing the assembly of a second such system (Coastal Zone Oceanography Section). The modification involved tasks such as the upgrading of the probe-to-surface communications link, the addition of a height-above-bottom measurement capability, improved processing software and recalibration of the sonic head. A "YO-YO" winch controller (Coastal Zone Oceanography Section) was also developed to facilitate shear probe operations.

The extendible transducer installation (Hydrography) aboard *Pandora II* was undertaken as a result of severe aeration problems which hampered survey operations. A study of the problem was conducted and a system utilizing a hydraulic ram to provide a two metre extension of the transducer was fitted in one of the ship's forward tanks.

Other tasks involved a Fluorometry data acquisition system (Ocean Ecology), PHAS consultations (Portugese Hydrographic Service), monitoring contracts (Hydrography) and continued consulting support to the various divisions of the Institute.

Technical Support Group

During 1978 the Technical Support Group provided installations, equipment preparation and field maintenance support in varying measure to the Western Arctic Survey (M.V. *Pandora II*), the West Coast Survey (C.S.S. *Parizeau*), the MacKenzie-Athabaskan Survey (M.V. *Radium Express*), the 1978-79 FGGE Tropical Experiment (C.S.S. *Parizeau*), numerous small coastal surveys (C.S.S. *Richardson*) and to major shore parties both in Vancouver and Silva Bay.

New field equipment added to the maintenance and installation inventory during 1978 included a Canadian Marconi Satellite Navigation System, two additional portable hydrographic acquisition systems (PHAS), a Motorola communications and paging system and a number of Loran-C and marine VHF receivers. Late in 1978, a Raytheon correlation echo sounder processor, CESP III, was received and will undergo field tests in early 1979.

The Institute radio base station installation XMH-59 was completed and with the exception of the antenna remote control capability, it is fully operational. To date the system has proven effective in providing excellent communications with department vessels from the Western Arctic to the equatorial Pacific. Among other projects and modifications the Group interfaced the Motorola paging system to PHAS which provided the data acquisition system the capability of paging an absentee watchkeeper.

MECHANICAL ENGINEERING

G.R. Smith - Project Engineer

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

In addition to Industrial Liaison activities, Mr. Smith has been providing general supervision of the Mechanical shops and mechanical engineering services. Mechanical engineering has been provided previously on a consulting basis, but the addition of an Engineering technician/draftsman, Mr. Redman, whose time is shared with Ships Division, will make it possible to handle routine design work efficiently. Typical requests in the past year were a tripod structure for supporting instrumentation under the hull of the Pandora II, provision of advice on *Pisces IV* equipment and the design of a retractable transducer ram for the *Pandora II*.

The Mechanical Support Group has been providing a high level of support to the users of the Institute Shops by way of assistance and advice. In addition to a major consolidation of shop facilities in mid-year, numerous projects were undertaken and completed. Projects included the construction of an under hull tripod (Institute Electronics), design and construction of an accelerometer calibration jig (Ocean Mixing), a zooplankton sorting device (Ocean Ecology), miniature pressure cases (Ocean Mixing), straightening of the Institute radio antenna mast (Institute Electronics) and the design and manufacture of special purpose connectors, elbows, plates, mounts, front panels, pulleys and such items for all sections of the Institute.

INDUSTRIAL LIAISON AND CONTRACT ACTIVITY

G.R. Smith - Industrial Liaison Officer

As a result of funding restrictions, it was predicted that considerable effort would be required to maintain the level of contract activity reached in 1977/78. In the past year, contracting has increased by approximately 20% and total expenditures for the year will exceed 2 million dollars. This increase was primarily due to bridge funding from the Department of Supply and Services, which enabled us to conduct a number of major projects. The most notable were a chemical baseline study, the development of a miniprocessor-based acoustic tracking system and improvements to the safety and operating capability of the *Pisces IV*. Results from these projects have been excellent and have generated interest from prospective customers in the private sector.

An interesting and perhaps significant change has taken place in 1978. There are now several new programs through which research and development can be undertaken by industry or through which contracted activities can be supported. Also the importance of non-government markets for products and services developing from contracts is being recognized. New support funding is not being made available directly to government departments but to companies willing to take the initiative in proposing useful projects. By involving contractors in the process of generating contract activity, transfer of technology should become more meaningful and an increased research and development effort by the private sector should result. With some encouragement, the companies involved in marine sciences have responded to this challenge and there are good examples of sound scientific initiative emanating from the private sector.

OCEANGRAPHIC DIVISIONS

P.W. Nasmyth - Regional Oceanographer

S. McKenzie - Secretary

Final consolidation of all oceanographic activities in the new facilities at Patricia Bay was completed early in 1978 and we have now experienced our first full year (almost) of operation as an "institute". The results are gratifying in terms of productive interaction between groups within the oceanographic divisions and between Oceanography and Hydrography. Plans are maturing for extensive cooperative and inter-disciplinary programs to be undertaken over the next few years. Our hope is that this sort of cooperation will lead to economies of operation as well as enhanced scientific output.

A general shortage of operating funds has resulted in some restriction in activities but has not yet had any serious impact on program. It may even have had some beneficial side effects by further encouraging economies through mutual support between groups and sharing of equipment and facilities. A negative result, if present trends continue, will be a reduction in funds available for contracting and a deterioration of the Institute's Make or Buy position.

In the continuous evolution of programs to meet present and anticipated demands for knowledge, certain trends have been felt this year. There will be a shift in emphasis from the inshore coastal waters of British Columbia to the Continental Shelf. While much remains to be done inshore, we have reached the stage of at least a preliminary understanding of the significant features of some of the more critical areas - whereas almost nothing is known of the oceanographic characteristics of the Continental Shelf or the mechanisms of offshore influence on coastal waters. Again this year our Arctic program has been heavily supported by non-OAS funds. There are indications that this outside support may be drying up, and if this trend continues, the result must be an overall cut back in Arctic activity together with more careful selection of programs on the basis of priority requirements.

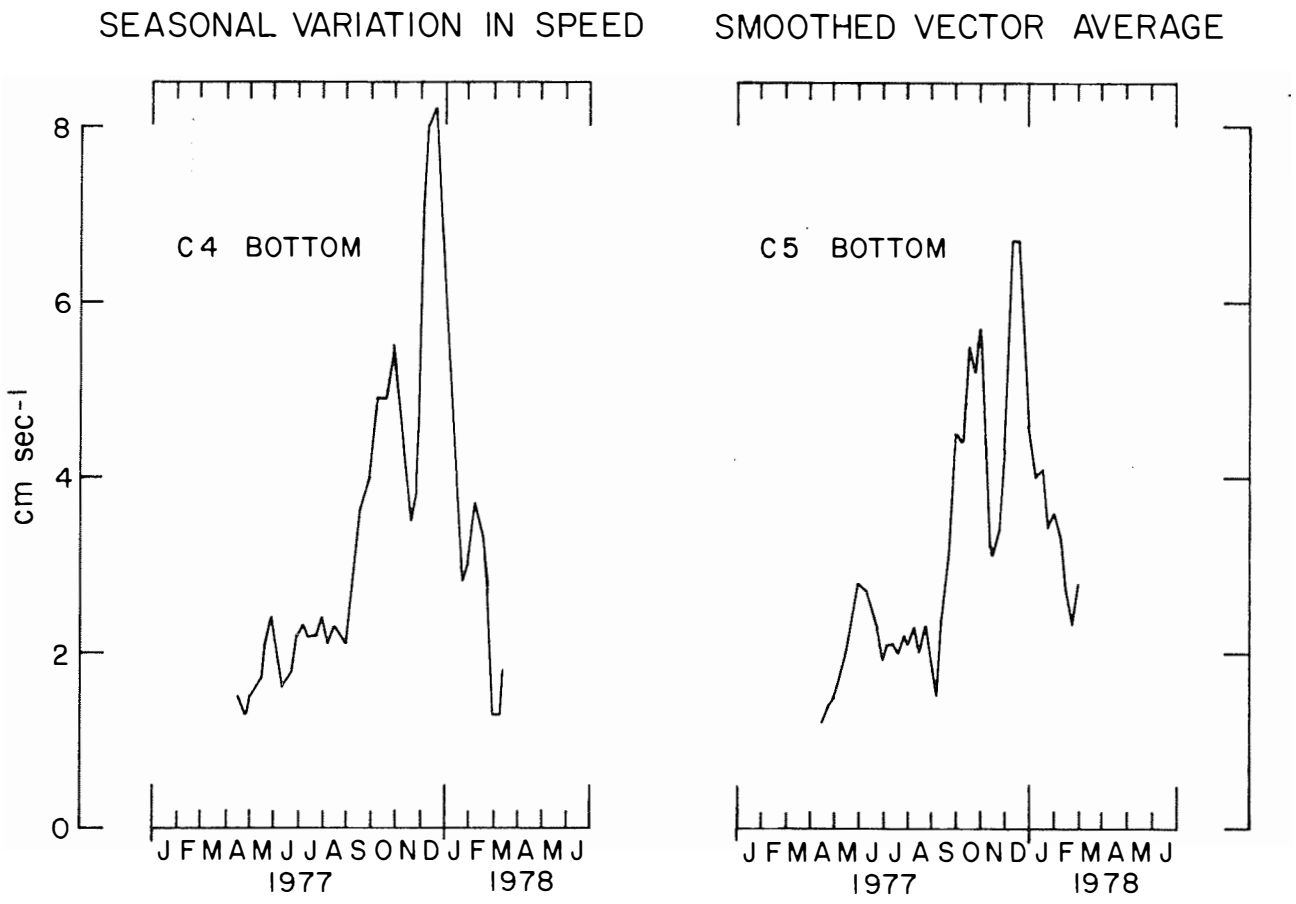
Three aspects of the oceanographic program have, in particular, this year attracted wide interest in the world oceanographic community:

i) the CO_2 balance between ocean and atmosphere,

ii) the dynamics of fjord systems, and

iii) the "drifting buoy" component of the First GARP Global Experiment.

All are treated in some detail in the reports of the separate sections which follow.



Observations of water movement near the bottom of Crozier Strait showing the weekly average current as a function of time. Surface and mid-water current meters which were suspended from the ice had to be removed in June 1977 to prevent their destruction by the ice. The records thus indicate (but do not prove) that there is a major increase in southward transport through the Strait in mid-winter.

OCEAN PHYSICS DIVISION

P.W. Nasmyth - Chief of Division

FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

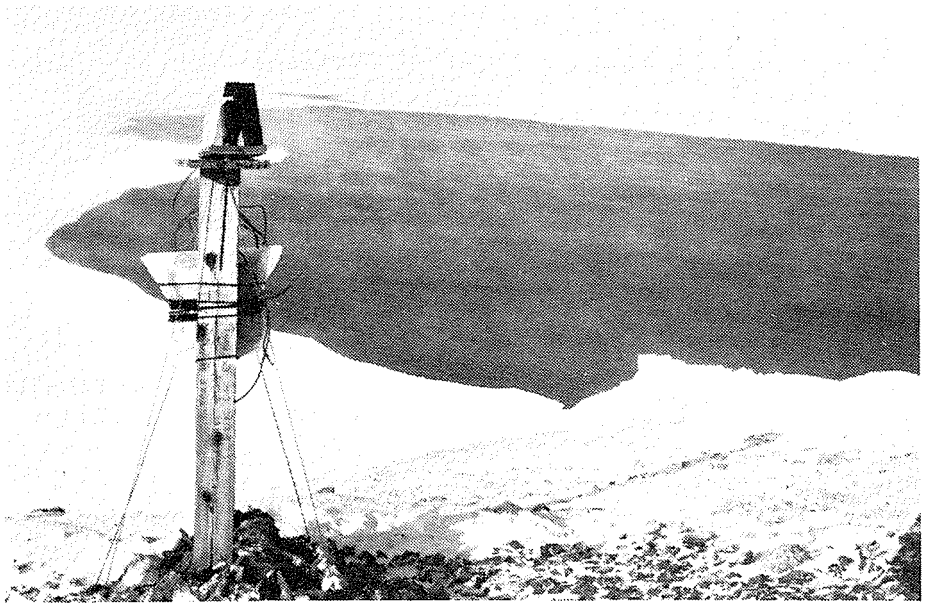
R.A. Cooke
P.E. Greisman* Postdoctoral Fellow
A.W. Koppel
R.A. Lake
J.M. McNeill
S.W. Moorhouse
R.G. Perkin
D.R. Richards
R.B. Sudar
D.R. Topham
E.R. Walker*
A. Wharton** Computing Services
M.E. Woodward* Computing Services

* Left in 1978
** Joined in 1978

During 1978 the Frozen Sea Research Group made field trips concerned with the measurement of currents in channels of the Canadian Arctic Archipelago, the oceanography of Bridport Inlet on the southern shore of Melville Island, and a preliminary investigation of the problems of taking measurements within polynyas (areas of open water within growing sea ice). Additional work has been done on instrument development, the physics of underwater oilwell blowouts, pollution in an arctic fjord, and the "Practical Salinity Scale (1978)" - a redefinition of salinity for seawater.

Current meters were recovered from Crozier Strait between Cornwallis and Bathurst Islands and the tracked vehicle train moved around the northern tip of the former island to deploy current meter chains in Wellington Channel. The CTD system in the oceanographic sledge has been interfaced with an HP 9825A minicomputer to provide a real time salinity and temperature readout. The data from Crozier Strait has been analyzed showing that currents were mainly tidal but suggesting that the residual southerly transport has a maximum around mid-winter, there being almost an order of magnitude difference between average summer and winter current speeds recorded at two current meters near the bottom. A major effort involved the deployment of sonically oriented current meter arrays in Wellington Channel, providing a direction reference independent of the earth's magnetic field and thus suited for use near the magnetic pole. The system was developed for the Institute under contract and work is continuing in the refinement of the design and on the analysis of operational data.

Bridport Inlet on the south coast of Melville Island is the proposed site of a PetroCan liquid natural gas (LNG) plant which would supply LNG carriers plying on a year-round basis between Bridport Inlet and markets on the east coast of Canada. The oceanography of the Inlet is important and has resulted in at least a two year study. One member of the group acted as an expert advisor, accompanying a contractor working for PetroCan in the Inlet in February 1978. Three members of the group collected data in the Inlet during late August when recording instruments were deployed for recovery in 1979, when further work will be done.



The polynya off the north of Dundas Island in April 1978. The picture is taken from the tip of Cape Collins 105 metres above sea level and shows the time lapse camera set up in the foreground. The polynya is of dimensions about 1.6 x 0.8 kilometres.

Operation of inflatable boats in the polynya in April. The men are wearing plastic foam exposure suits as a protection against accidental immersion in the water.

The polynya existing off Cape Collins on Dundas Island (76°08'N, 95°00'W) was investigated to define problems in logistics and equipment design encountered in operating on the polynya and the surrounding ice sheet at air temperatures ranging to -30°C. This was the first year of a proposed three year program of cooperative studies of air/sea energy exchange being conducted with the Bedford Institute of Oceanography and the Atmospheric Environment Service, Downsview, Ontario. The latter department successfully operated one of their instrument towers close to the base camp.

The design of a new salinity cell suitable for use on a chain has been published and the first such chain deployed. Investigation of the long-term stabilities continues. A major effort has gone into the development of electronic packages for model aircraft to be used to investigate temperature fields above polynyas. Work is progressing on the data package designed to telemeter temperature and pressure information and, using a photosensor, to allow the ice/water edge to be detected when traversed by the aircraft. A system enabling the position of the aircraft to be determined utilizing a Decca mini fix system should be available by the spring of 1980.

Further work has been done on data acquired during the simulated shallow oilwell blowout conducted in 1976, with a view to obtaining a more accurate understanding of the bubble plume. Work under contract has continued at the Department of Chemical Engineering, University of Calgary to investigate such phenomena as hydrate formation which will occur during a deep oilwell blowout. Hydrate formation, a theoretical possibility under the pressures and temperatures to be expected in arctic waters below about 150 metres were shown to occur by a gas release from the submersible *Pisces IV* in Jervis Inlet, B.C. These results have now been duplicated in the vertical high pressure water tunnel which has been built in Calgary. Problems of supersaturation of gas in oil drops during ascent to the sea surface are also being studied and it is hoped that a complete picture of deep oilwell blowout dynamics will be available early in 1979 to enable a proper scenario to be written. A study of the natural disposition of oil and gas arriving at an ice/water interface has shown that oil will lie below the gas bubble unless in sufficient quantity to spill over and upwards onto the surrounding ice.

Studies made of pollution in a fjord on the west Greenland coast resulting from mining operations at Mârmorilik demonstrated the effect of the rejection of salt by sea ice during growth on vertical winter circulation and pollutant movement. We have deployed recording instruments in this fjord in conjunction with the Danish Geological Survey program.

The group has been very active in studies leading to the new "Practical Salinity Scale (1978)" due to be promulgated shortly in order to standardize salinity observations taken throughout the world.

Frozen Sea Research Group recovers surface units from the sea ice of Wellington Channel. Note the telemetering antenna on the left of the picture. Data acquired by current meters is transmitted sonically to the surface and hence by radio telemetry to a recorder on a local hilltop.

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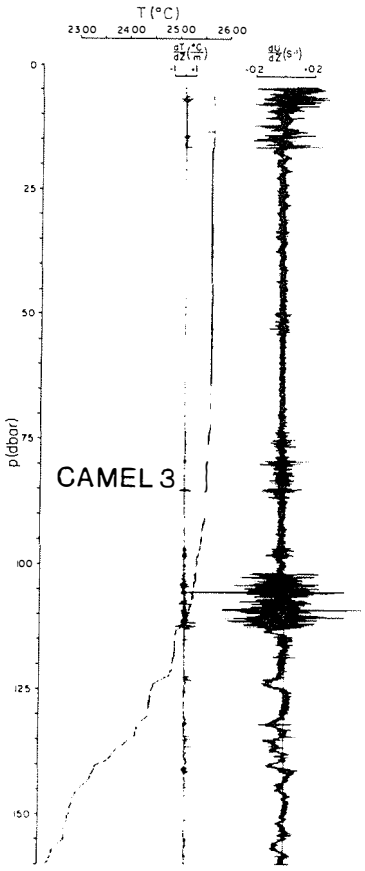


By measuring turbulent velocities in the ocean surface mixed layer, we hope to contribute to an understanding of the dynamical processes which link the atmosphere and the oceans. This profile of small-scale shear (dU/dz) was taken through a surface mixed layer in the Sargasso Sea, using the Osborn profiler CAMEL. At a time of active wind forcing, turbulence driven directly from the surface appears to be confined to the upper 15 dbar of the water column, while mixed layer deepening may be associated with the patch of strong shear at the mixed layer base around 110 dbar.

OCEAN MIXING SECTION

P.W. Nasmyth - Head

G.G. Chase
A.E. Gargett
R.C. Teichrob

This year analysis of data from the towed system was completed, with publication of results from an investigation of the relationship between finestructure and microstructure in the frontal region between coastal and offshore water masses along Line P. Ocean Mixing may undertake further investigation of ocean frontal activity as part of a cooperative experiment with other Canadian and U.S. agencies in 1980 to study the subtropical front in the North Pacific. This would also be a first venture offshore with *Pisces IV*.

A study of turbulent dissipation levels in the surface mixed layer, as observed during two occupations of a site in the middle of the Sargasso Sea during the 1975 cooperative Fine and Microstructure Experiment, has been completed and will appear in the Journal of Physical Oceanography. A data report on the complete results obtained during this experiment will shortly appear as an Institute of Oceanography, University of British Columbia Manuscript Report (with T. Osborn). A journal paper is also being prepared. Experience gained with analysis of this data from the Osborn-Siddon "shear probe" has proved valuable, and we now incorporate the use of similar probes as part of the *Pisces* system.

The modified sensor system for *Pisces IV* proved largely successful in trials in early 1978, with two significant exceptions. Electronic interference from the acoustic current meter picked up in other components of the system proved to be very persistent and of such magnitude that some signals were of little value. Secondly, the new data acquisition system based on Emerson digital cassette units was not sufficiently far advanced for a realistic trial. The acoustic current meters were replaced with a three-dimensional array of small propeller-type meters developed at the University of Washington.

Further trials in November with an almost completed data acquisition system were completely successful and good data were obtained in two situations; (a) in the mixing region in the outflow of the Fraser River in the southern Strait of Georgia, and (b) in mixing zones and through unstable internal waves generated by tidal flow over the sill in Knight Inlet. The latter was done in conjunction with the measurements taken from the surface by Coastal Zone Oceanography and should lead to an estimate of the amount of tidal energy lost to turbulence in flow over the sill. With measurement of all three components of velocity with a spatial resolution of 2 - 3 cm or better it should be possible for the first time to get a quantitative indication of the isotropy of the dissipation scales of the turbulent field. Analysis of the data is in progress.

COASTAL ZONE OCEANOGRAPHY

D.M. Farmer - Head

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

This year Coastal Zone greatly extended its earlier program to study the dynamics of tidal interaction with sills and its influence on circulation. Analysis of data has led to new theoretical approaches applicable to deep estuary flows and a laboratory model has been used to simulate some of the processes thought to occur in nature.

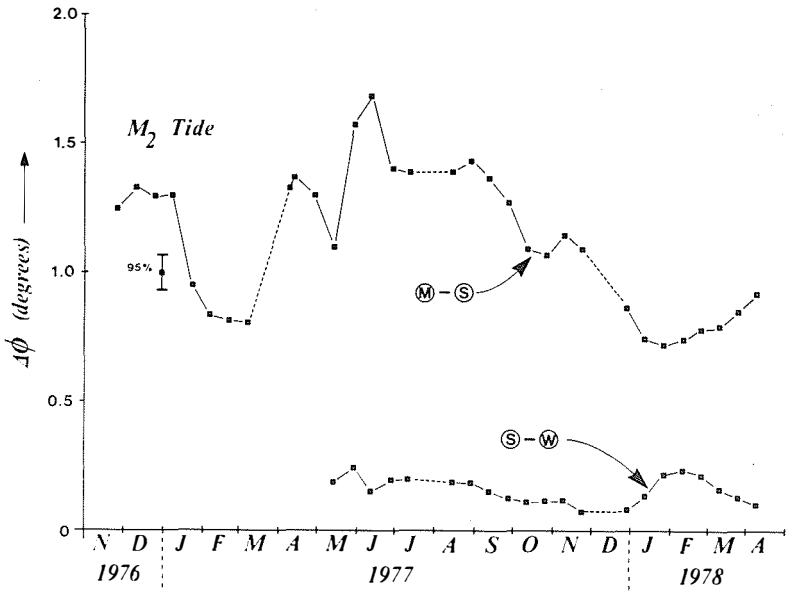
Ongoing work includes the detailed analysis of tidal exchange between the Quatsino and Rupert-Holberg inlet system, the further development of a mooring model and maintenance of the daily salinity/temperature sampling program from B.C. light stations. The integration of a profiling current meter/CTD with real time shipboard display of data has proved a valuable addition to our experimental capability. Oceanographic projects managed by Coastal Zone included the concluding phase of the study of circulation in the channels leading to Kitimat as well as two studies of Alberni Inlet related to the ocean dumping problem.

Dynamics of Flow over Sills

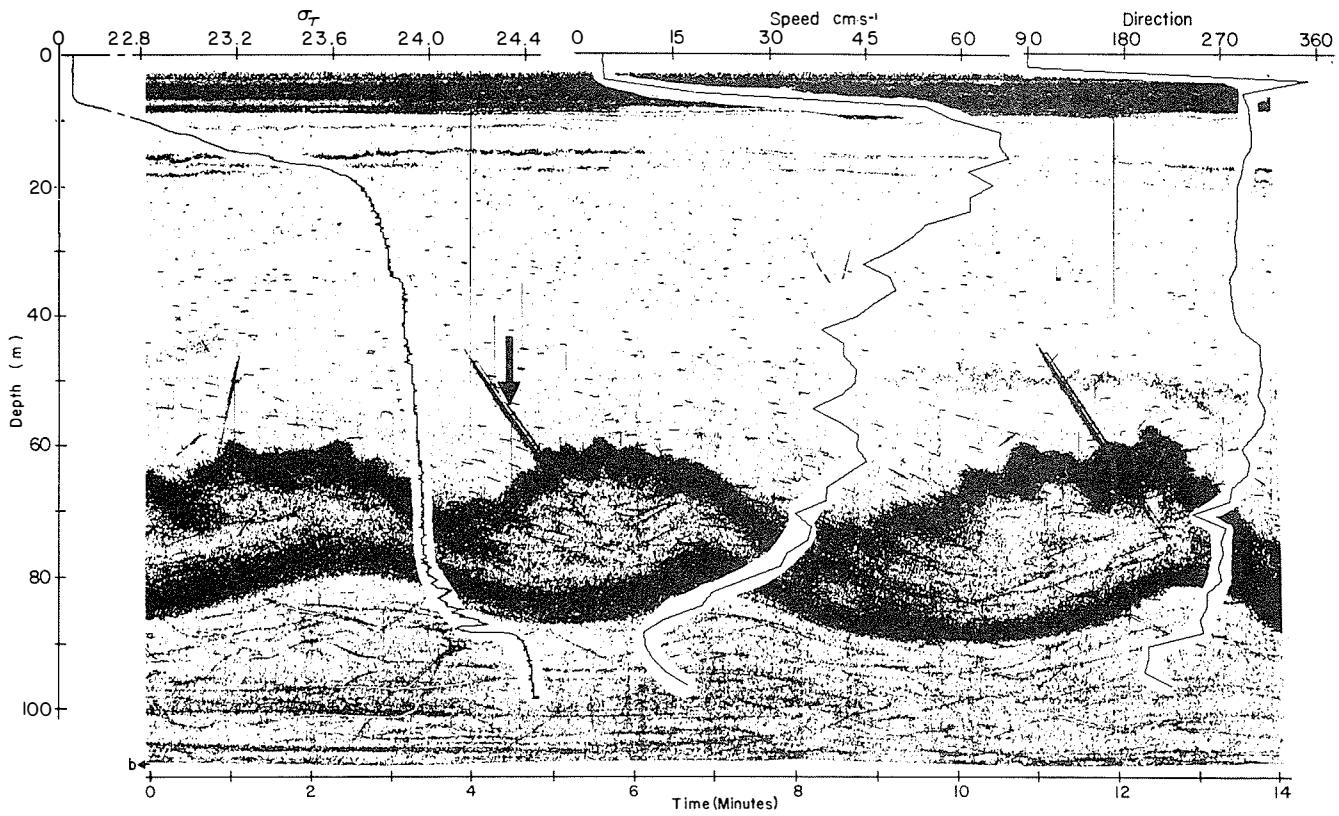
In this second year of studying the circulation in Knight Inlet, we have continued to take salinity-temperature profiles at monthly intervals, have made a precise and detailed tidal survey of the inlet and used a current-meter mooring to study the structure of the internal tide. In July we were again joined by Professor J. Smith with the University of Washington vessel *Onar*. In an intense three-week cruise we used fixed depth and profiling CTD/current meters, together with acoustic techniques, to explore the detailed structure of tidal interaction with the sill, the dynamics of which had only started to become apparent at the very end of the previous joint cruise in 1977.

These more detailed observations revealed a remarkable variety of phenomena. Early measurements with the two vessels confirmed that, at least near the sill, the flow was essentially two-dimensional. Phenomena that could be interpreted as hydraulic jumps were observed, but in contrast to our expectations, summer measurements showed that the structures behaved like mode 2 waves, with the streamlines splitting just upstream of the sill crest. We also observed mode 2 lee waves and, much later in the year when the stratification was weaker, mode 1 lee waves. Separation on the bottom boundary layer was also tracked, both with current-meter profiles and acoustically, and the separation point appears to be closely linked to the shape and position of the lee waves.

The longer term measurements of tidal height and density structure have provided the basis for development of a two-layer circulation model. This theoretical model has been used to examine the divergence of potential energy flux in Knight Inlet and provides a basis for interpreting observations of tidal energy loss and resultant mixing near the sill. The fraction of tidal energy available for mixing is sensitively dependent upon the stratification and can be observed through small changes in the phase angle of the tide across the sill. Current meter observations, in turn, have shown how tidal mixing influences the estuarine circulation. A significant fortnightly (MS_f) component of flow occurs in the currents, but has no corresponding signal in the tidal height observations. This result is consistent with the concept of stronger estuarine circulation associated with the stronger tidal mixing occurring during spring tides.

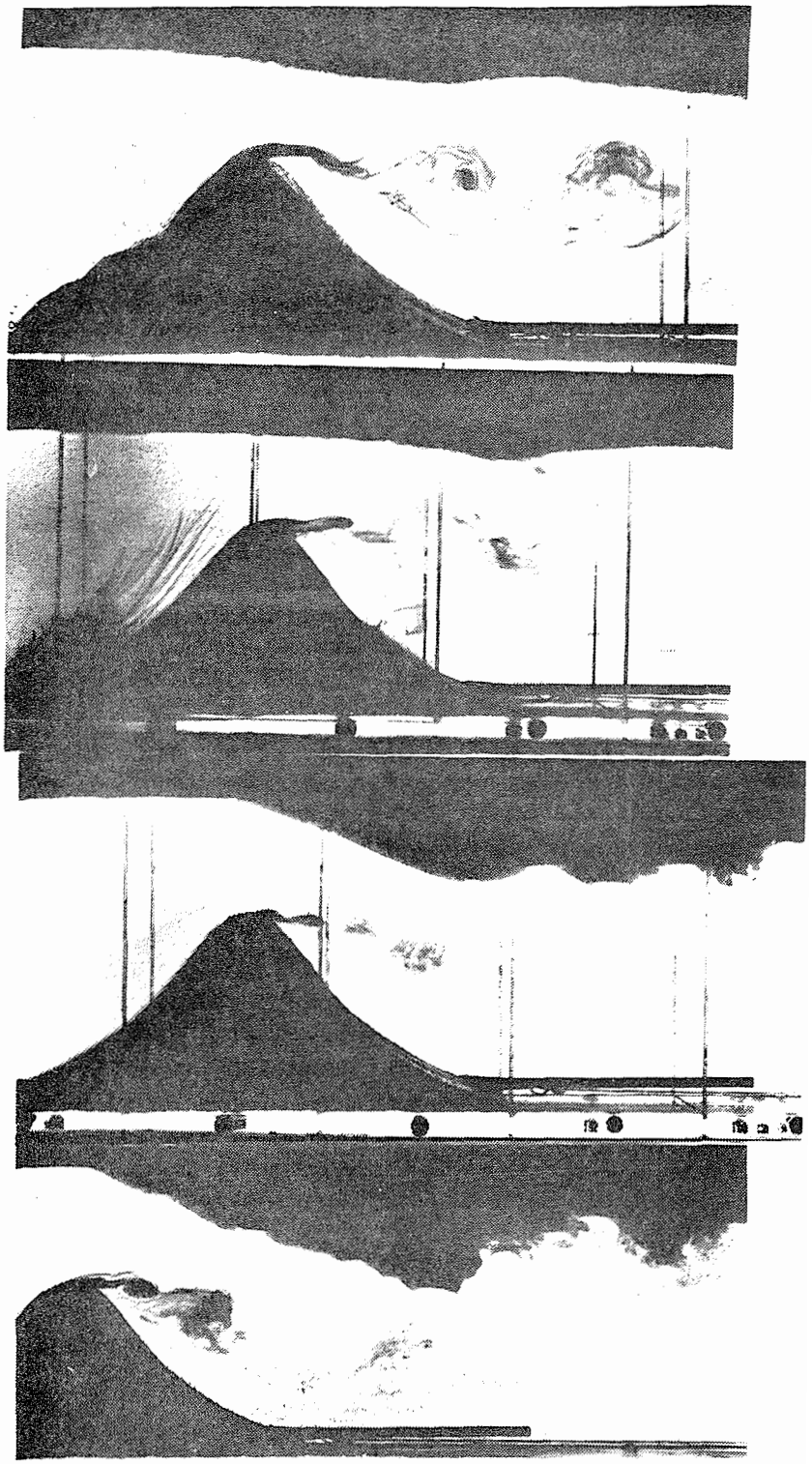


The M_2 tidal component in Knight Inlet shows a large change in phase between two stations, labelled M and S in the figure above, and a small change between S and W. In fact stations M and S are closer to each other than the stations S and W. Furthermore, the phase difference between M and S shows a large seasonal variability. We attribute the large lag to internal wave generations, and similar processes, by the tidal flow over the sill in the inlet; a process that extracts energy, locally, from the barotropic tide. Since the stratification is seasonally dependent, the energy that can be put into internal motions is also seasonally dependent.



This figure shows profiles of water density (left hand curve), current speed (center) and direction (right), superimposed on an acoustically derived image of flow near a sill in Knight Inlet. The wave-like feature in the lower part of the figure is associated with a free shear layer separating the swiftly moving water above from the nearly motionless water benearth. Sloping line (arrowed), shows path of profiling instrument.

A simple laboratory model in which a small obstacle is towed back and forth in a tank of stratified water has been used to study some of the processes that might be occurring in nature. A striking aspect of these studies has been the observation of the way in which boundary layer separation can be suppressed under certain conditions of stratification and the significance of boundary layer separation to the overall response.



Two-layer flow over a steeply sloped obstacle is modelled in this tank experiment, used to explore effects of tidal interaction with sills in coastal waters. Four separate runs, at progressively higher speeds, show the transition from relatively weak lee waves to more violent phenomena similar to those observed in Knight Inlet. The upper, dark layer is fresh water, the clear fluid is salt water; dye crystals placed to the left, just ahead of the sill, trace the path of vortices shed from the sill crest.

The Tidal Jet in Rupert-Holberg Inlet

Observations of the tidal jet issuing from Quatsino Narrows into Rupert-Holberg Inlet reveal that there are two types of discharge; a buoyant surface jet characterized by strong surface currents, and a negatively buoyant flow characterized by strong bottom currents. Observations of the buoyant jet have been compared with the results predicted by existing models of heated surface discharges in which the behaviour of the discharge is determined by the initial densimetric Froude number of the flow. Based on this parameter, the agreement between the predicted and observed vertical penetration of the jet is good.

Precipitation, through its influence on the density of the surface, appears to be the dominant factor controlling the type of discharge, although upwelling and tidal amplitude may also play an important role. The rapid and frequent exchange of the deep basin waters resulting from the intense tidal mixing of the jet gives this inlet a character atypical of shallow silled fjords. (D.J. Stucchi).

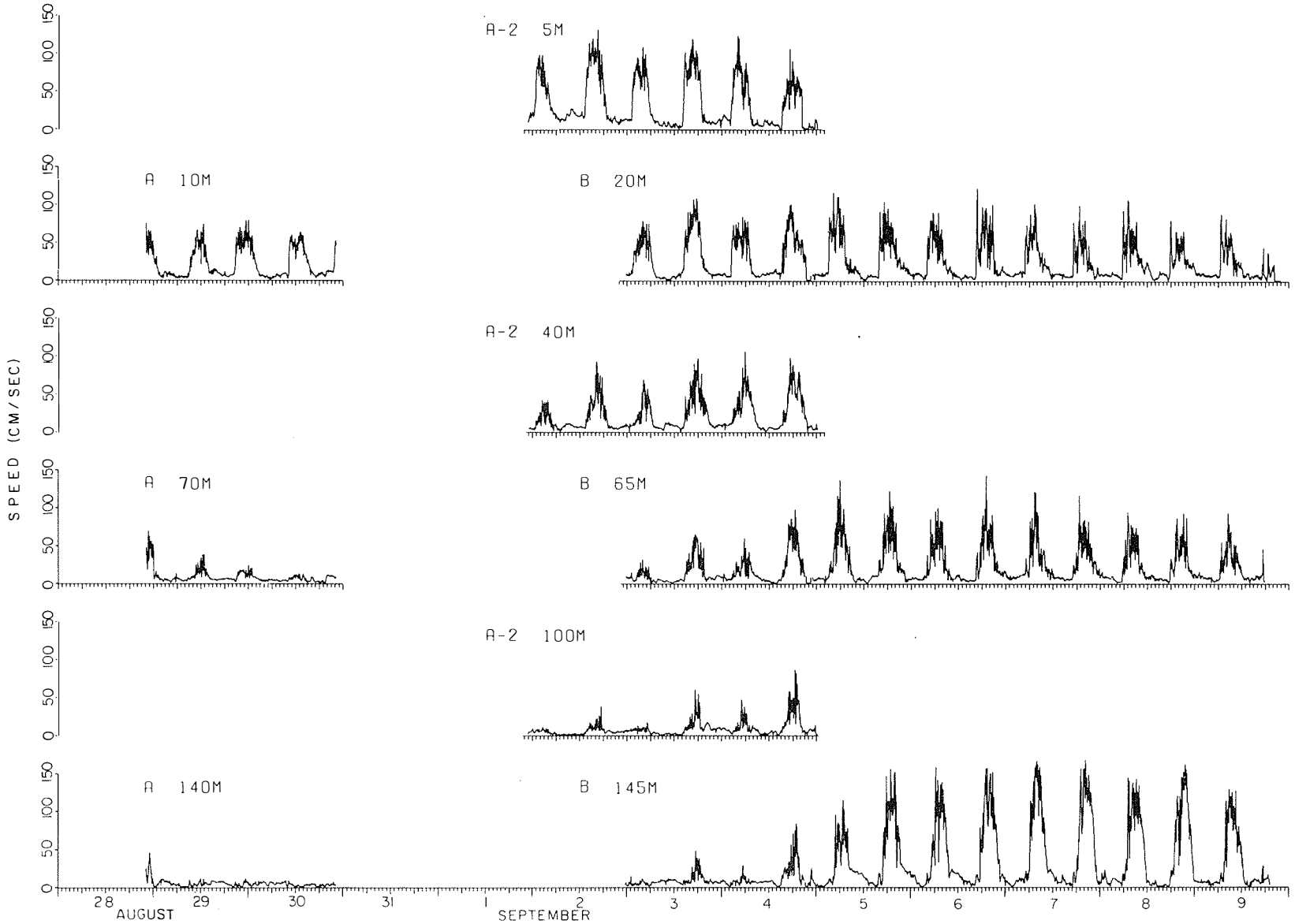
Mooring Techniques

Investigation into mooring problems was continued with an examination of strumming problems and of the influence of turbulence on drag. Development of a 3-dimensional static mooring model was begun, as an aid in examining oceanographic data obtained from sub-surface-moored instruments. Assistance with mooring problems was provided to other groups in the Institute.

We acquired and tested the new Neil Brown Acoustic Current Meter. Unfortunately an electronic fault prevented a full data recovery, but initial results look hopeful and translation and data processing software have been developed. Further tests will provide the basis for evaluation of this instrument. (W.H. Bell).

Instrumentation Development

A significant development, in co-operation with other groups in the Institute, was the integration of a profiling CTD-current meter with real-time shipboard data processing. Plots of current speed and direction and of salinity (or density) generated as the data are acquired, enormously improved our ability to interpret results in the field during the study of rapidly changing processes such as tidal flow over sills.



Current speed data taken on the axis of the tidal jet in Rupert-Holberg Inlet showing the initial period of buoyant flow followed by a transition to strong bottom currents (negatively buoyant flow).

Ocean Dumping

The watching brief on developments in ocean dumping technology was continued, with the production of a further review of papers relating to the physics of dumped material disposal. Two contracts relating to dumping in Alberni Inlet were let, one dealing with a model of the internal tide and the other with the variability of coastal upwelling and the consequences of flushing of the inlet.

Plans were laid for a new program of research in Alberni Inlet which will examine the exchange of water in the deep basins in some detail. (W.H. Bell).

Kitimat Study

This year the observations undertaken as part of a study of circulation in the complex of channels leading up to Kitimat were concluded and write-up of the results is near completion. This work is being conducted under contract and was motivated by concern over possible port developments at Kitimat. The project has included an analysis of the estuarine and wind-driven response and also of the tidal circulation. Final reports of this study will be available in early 1979.

Saanich Inlet Deep Water Renewal

Several moored instruments were placed on and inside the sill of Saanich Inlet from August to November of 1978. Preliminary examination of these data reveal that at least 3 events of deep water renewal occurred during the period. The denser renewal water is observed at the sill for periods of 5 to 7 days, coincident with times of large tidal ranges. Although the renewal water is of limited vertical extent (10 m or less) its inflow velocities are relatively large (60 cm/sec maximum). Future work will be directed towards the identification of the source of the renewal water, and the determination of the importance of those events to the exchange of the deep basin waters. (D.J. Stucchi, L.F. Giovando).

Continental Shelf/Alberni Inlet Project

Plans were laid and preparations made for a study of upwelling and other phenomena on the continental shelf off Vancouver Island, starting in January 1979. Simultaneously a study of deep water exchange, which is thought to be associated with the upwelling, will be carried out in Alberni Inlet. The project will involve extensive current-meter and CTD observations and will be integrated with other programs in the same area being carried out by other groups in the Institute.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett - Head

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

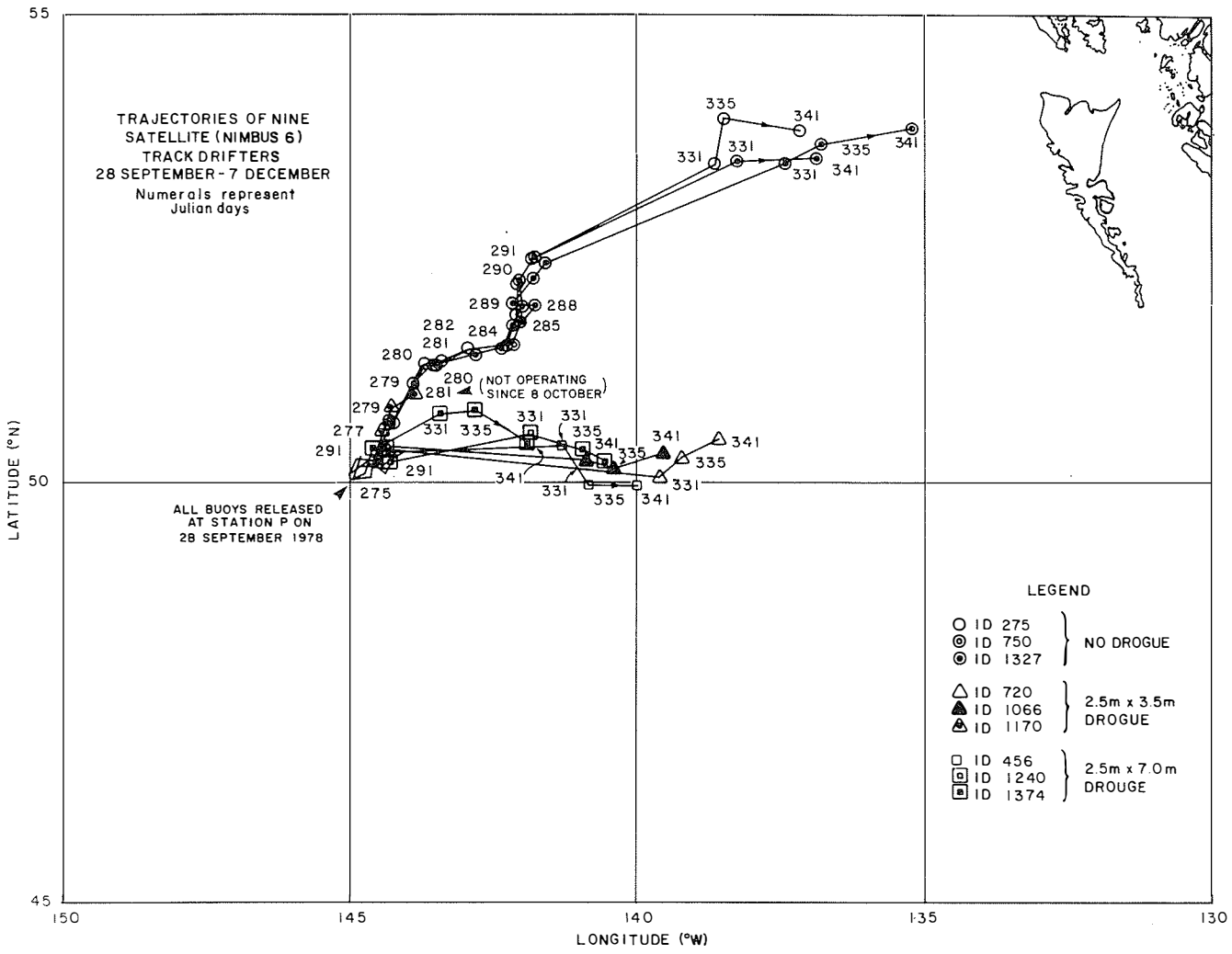
*Joined in September 1977

The main efforts of the Offshore Oceanography Section this year have been directed towards continuing observations and examination of data taken at Station P, Line P and other areas of the eastern North Pacific Ocean; obtaining data in coastal seaways, notably in Johnstone Strait and southern Strait of Georgia-Juan de Fuca Strait; examining drifting buoy trajectories in the open ocean and testing recently developed instruments - the current shear probe developed at IOS, the commercially-available expendable conductivity-temperature-depth probes (XCTD) and expendable sound velocity-temperature-depth probes (XSVTD).

Dr. J. Garrett is spending approximately one year at the Service Argos/FGGE (First Garp Global Experiment) Buoy Control Centre - Centre National D'Etudes Spatiale in Toulouse, France, where he is managing the international FGGE buoy observing system and data processing associated with it.

Climatology and Large Scale Air-Sea Interaction

The oceanographic time series programs at Ocean Station P and Line P have been continued into their 23rd and 20th year respectively. Due to the rising overall cost of maintaining the program it has been found necessary to reduce the level of effort devoted to make field observations. This has been done by sending an oceanographer on only one instead of the two weatherships. An appreciable amount of time was spent this year editing the data collected up to the end of 1976. Data of dubious quality have been removed from the working weathership data sets. However, all the original data "as observed" will remain in the original data sets. A cursory examination of the Station P data has revealed the occurrence of important climatic changes of water to a depth of at least 500 m. For example, at a depth of 200 m, well below the level of direct seasonal influence of atmospheric forcing, temperature changes of approximately $2^{o}C$ have occurred within the relatively short period of 1-2 years. In particular, the years 1960 and 1974, were characterized by the presence of water of relatively high temperature whereas 1965 was featured by water of low temperature. The warm waters in 1960 and 1974 were also characterized by lower oxyty (concentration of dissolved oxygen) than normally observed at Station P. (Tabata).



Trajectories of nine satellite (Nimbus 6) tracked drifters during 28 September - 7 December 1978. Three buoys (I.D.275, 750, 1327) have no drogues, three (I.D. 720, 1066, 1170) have 2.5 m x 3.5 m drogues; the remaining three (I.D. 456, 1240, 1374) have 2.5 m x 7.0 m drogues. All buoys with drogues except one (I.D. 1170) drifted more slowly than the undrogued buoys. (It is suspected that the drogue suspended from buoy 1170 has fallen off.)

All available STD and bathythermograph temperature data collected along Line P since 1968 are being processed to determine spatial and temporal variations in oceanic "noisiness" levels (mean variances) off the British Columbia coast. Results indicate that the generally rapid decrease in temperature fine-structure away from the continental shelf to more quiescent deep-sea waters is frequently disrupted by the presence of pronounced ($2^{o}C$) intrusions of cold and warm water. Three dimensional plots of the spatial variability of temperature variance along line P are being prepared. (Thomson).

A SEASAT wave rider buoy and a Roll-and-Pitch buoy were both deployed at Station P during 1978 on behalf of the NOAA agencies.

In order to determine the effect of winds and waves in the Canadian FGGE drifting buoys, nine buoys comprising three without drogues, three with short drogues (2.5 m x 3.5 m) and three with long drogues (2.5 m x 7.0 m) were released at Station P ($50^{o}N$, $145^{o}W$) and their drifts monitored. The drogues are suspended a few metres below the buoys. Based on 66 days of observations, the results showed that the undrogued buoys travelled northeastward at an average speed of 12 km/day while the drogued buoys travelled eastward at less than one-half of the above rate indicating that the undrogued buoys are affected considerably by the winds. (Garrett).

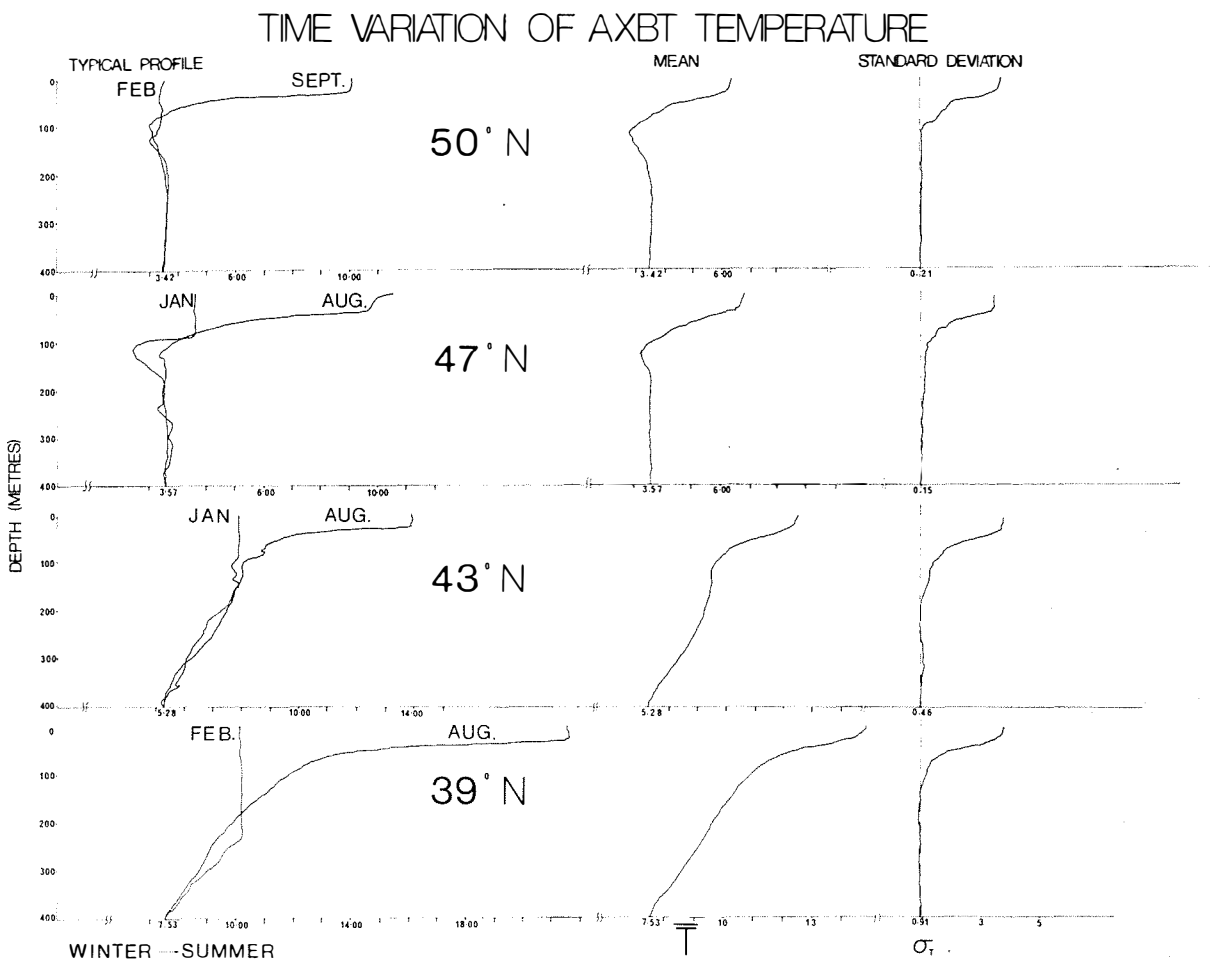
Ocean Response Study

In order to understand the role of the Pacific Ocean in influencing the climate of North America, it is essential to understand the mechanism which produces change in the sea surface temperature. This has been the motivation for the study of upper ocean dynamics of the top 300 metres.

Offshore Oceanography has been participating in international experiments focussing on two areas. MILE (a mixed layer experiment) was staged August-September 1977 with three ships in the vicinity of the Ocean Weather Station ($50^{o}N$, $145^{o}W$). This experiment involved direct measurement of currents, salinity and temperature over a horizontal scale ranging from 150 kilometres to a few hundred metres and on a vertical scale from the surface to 300 metres. The Institute scientists, with the assistance of Canadian Forces Argus aircraft, determined the meso-scale structure and its time evolution. The most important finding indicates that local surface heating accounts for only 60% of the heat exchanged in the upper 100 metres of the ocean, while the remaining 40% is due to advection at various depths and with different time scales. The mechanisms responsible for these findings have been identified.

The other major area of activity involved participation in the NORPAX anomaly dynamics study. An AXBT survey of a North Pacific area with dimensions 15^{o}(N-S) x 5^{o}(E-W) continued throughout 1978. Analysis of the data indicates that subsurface advective processes play a major role in establishing stability in the entrainment region of the mixed layer. These results reinforce the findings of the mixed layer experiment.

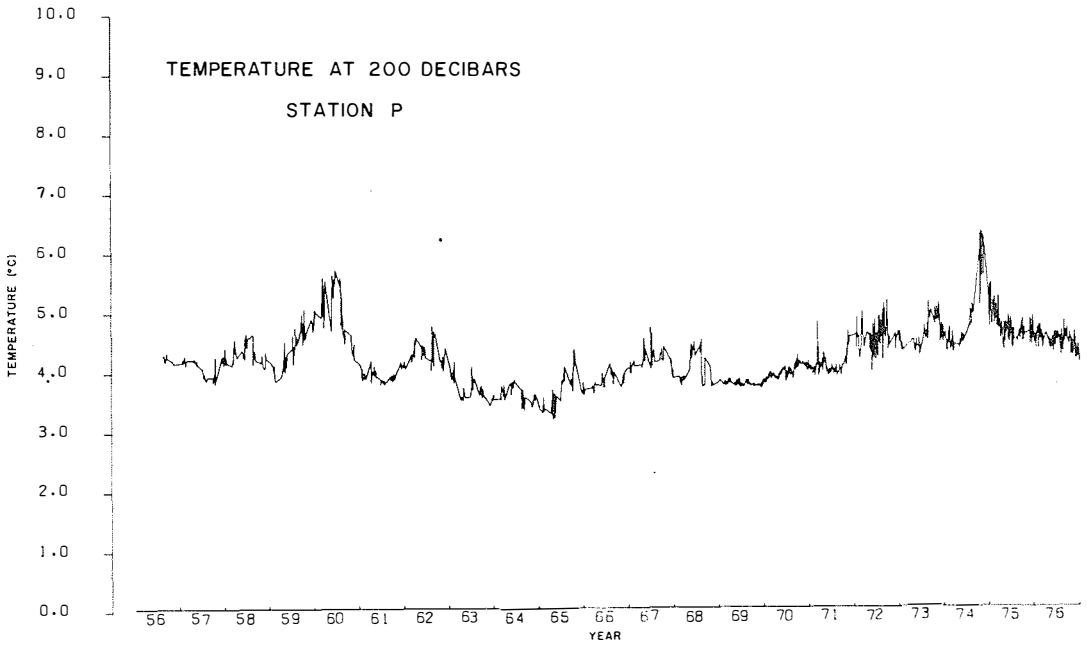
Latitudinal Variation of Upper Ocean Temperatures



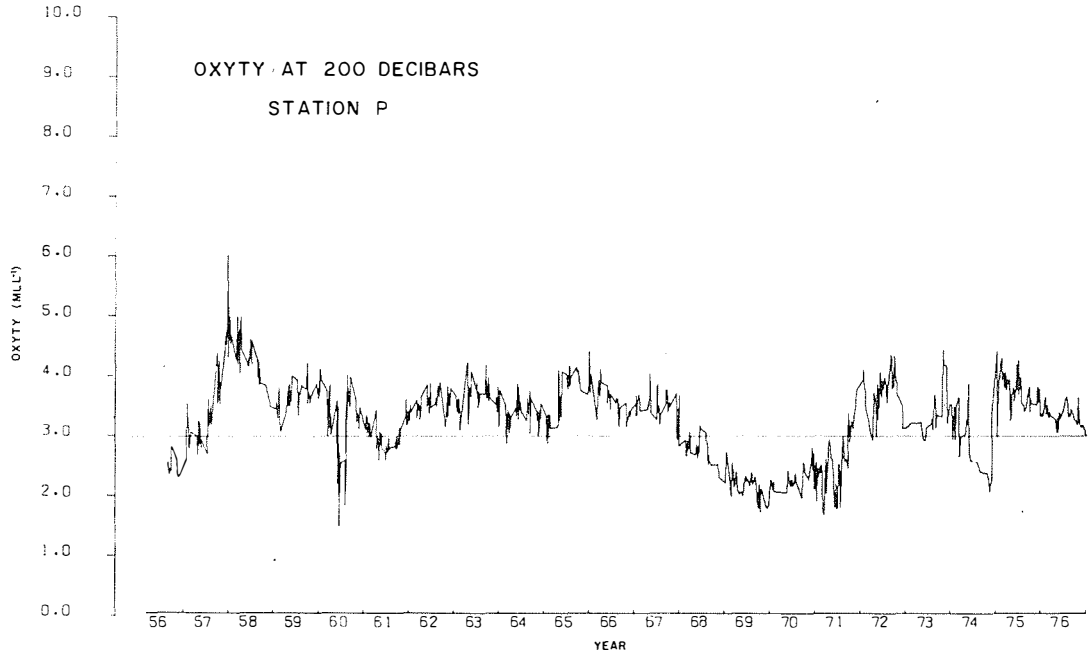
During an AXBT flight every two weeks the latitudinal variation of the temperature structure in upper 400 metres was determined. Analysis of mean temperatures suggests cold water advection below the seasonal thermocline in high latitudes and warm advection below the halocline in low latitudes. The crossover latitude coincides with the sub-arctic frontal zone.

The residence time of these advecting intrusions appears to be of the order of 2 months, with dimensions normally in the order of a few hundred kilometres but in some cases only of the order of few 10's of kilometres. The relative importance of the scale of these inhomogeneities requires further analysis. (Miyake).

Examples of Time-Series Record at Station P, 1956-1976



At depths well below the level of direct seasonal influence of atmospheric forcing (approximately 200 metres) the temperature undergoes relatively large climatic changes, with high temperatures occurring in 1960 and 1974 and low temperatures in 1965. The difference between the maximum and minimum is just over 3°C.



The oxyty also undergoes large climatic changes, varying from a maximum (>5.3 ml/L) reached in 1957-1958 to a minimum (<1.6 ml/L) in 1969-1971.

Variability of water properties in the surface mixed layer

It has been known for some time that the surface mixed layer of the ocean is generally isothermal to within ±0.03°C. However, in order to determine to what greater degree, if any, the layer is uniform or variable in temperature, salinity and concentration of dissolved oxygen (oxyty), time-series oceanographic data based on hydrographic stations obtained at Ocean Station P (50°N, 145°W) from 1956 through 1976 have been examined. The surface mixed layer is found to be homogeneous in temperature, salinity and oxyty to within the present accuracy of standard measuring techniques. The water within the layer is isothermal to within ±0.02°C during the cooling season (October through March) and to within ±0.03°C during the heating season (April through September). It is isohaline to within ±0.003°/oo, and iso-oxygenic to within ±0.05 ml/L, during both seasons. The determination of the actual variability of temperature and salinity within the layer is limited by the accuracy of the instrumentation employed. On the other hand, that of oxyty is somewhat higher than would be indicated by the precision associated with the methods used. This is attributed to sampling errors. The determination of the variability should have important bearing on the studies of microstructure in the mixed layer and of surface mixing processes. (Tabata).

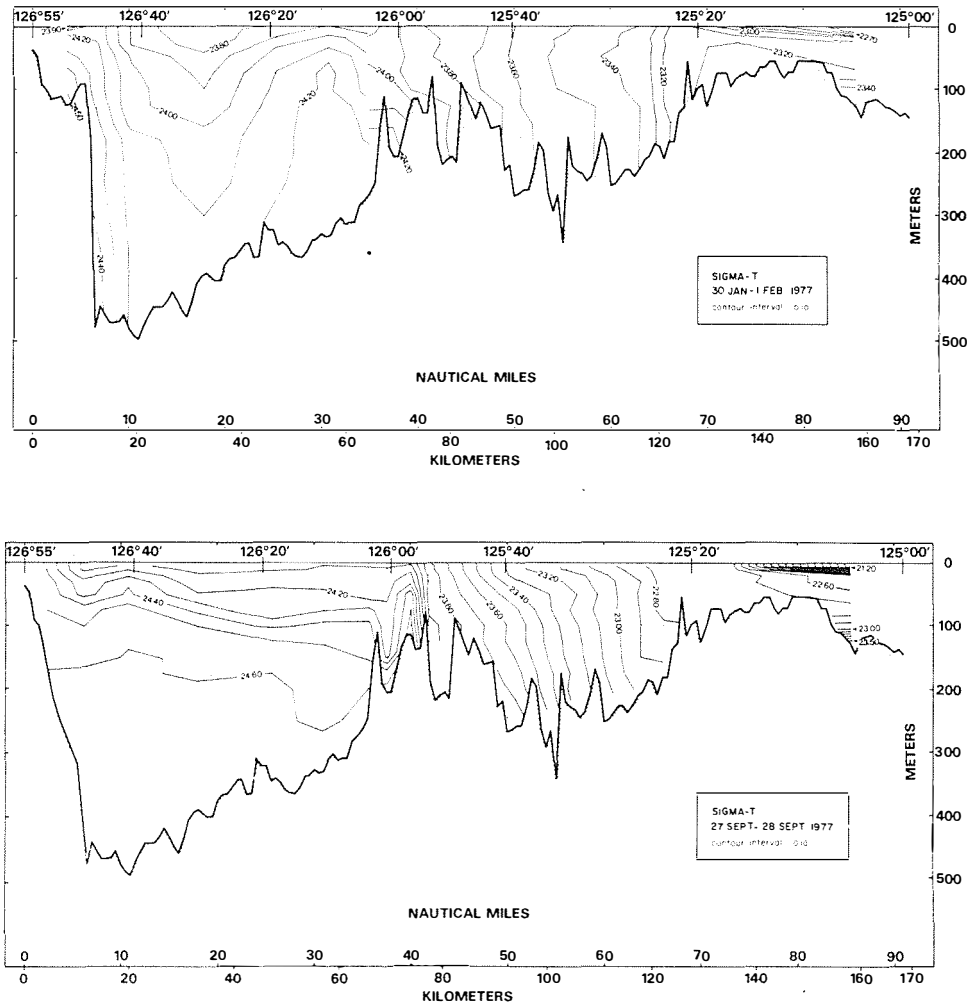
Oceanography of the Continental Shelf

Johnstone Strait Region

Deployment of six current meter moorings in the vicinity of the Newcastle sill in Johnstone Strait during June completed our investigation of the physical oceanography of the Johnstone Strait region. In conjunction with the Tides and Currents section 1½ years of data have been collected at approximately 3 month intervals from the northern Strait of Georgia to Queen Charlotte Strait. Most of these data have now been reduced and plotted and should be ready for presentation in atlas form by mid-1979. (Thomson).

Currents and density profiles obtained near the Newcastle sill in Johnstone Strait are being analyzed in terms of a seaward progressive internal tide. This baroclinic motion appears to be dominated by the first vertical mode with a considerably smaller second mode. The superposition of mean-estuarine flow, barotropic tidal current and the first two baroclinic modes accounts for all but a few percent of the flow variance. This work should be completed for publication in 1979. (Thomson).

Side scan sonar tracks have revealed the presence of a sand-ripple patch extending 2 km seaward of the base of Newcastle sill in Johnstone Strait (Fig.). The sand waves are about 1 metre high and have wavelengths of order 100 metres. An investigation with the *Pisces IV* submersible revealed that the crests were oriented at an angle to the tidal currents and that there is no superficial difference in sediment type between the rippled and non-rippled areas. Work is continuing with Tides and Currents Section and the Pacific Geoscience Centre on this project.



Examples of longitudinal sections of water density (sigma-t) along the inside passage between northern Vancouver Island and the mainland. Sections run from Alert Bay (Broughton Strait) on the left to Cape Mudge (Strait of Georgia) on the right.

Southern Strait of Georgia

In conjunction with the Tides and Currents section and Numerical Modelling section, a four month investigation of the currents and physical oceanography of the Boundary Passage Region was undertaken. As part of joint effort with Pacific Marine Environment Laboratory, Seattle, the work was also extended to include current measurements off Race Rocks and CTD profiles from Cape Flattery to Texada Island in the Strait of Georgia. Data has been reduced but not analyzed.

NUMERICAL MODELLING SECTION

R.W. Stewart - Head

P.B. Crean
R.F. Henry
P.J. Richards - Computing Services
*T.S. Murty
M.G. Foreman - Computing Services
J. Stronach (Postdoctoral Fellow)

*Joined in 1978

The section continues to provide support for other groups in the Institute through the development and application of numerical models for simulation of oceanographic conditions in areas of high priority.

Numerical modelling studies of the Georgia/Fuca system in 1978 were characterized by a shifting emphasis from barotropic tides to considerations of the estuarine circulation.

The two dimensional vertically integrated fine grid (2 km mesh) model of the southern part of the system was extended into the northern Strait of Georgia, partly to provide input to an extended version of the "upper layer" buoyant-spreading model of the Fraser River plume, and partly with a view to performing studies of residual circulation induced by the barotropic tide. It presently appears that further aspects of the barotropic tidal work, primarily concerned with local coastal engineering applications, will be carried out in the private sector.

Work on the "upper layer" buoyant-spreading model of the Fraser River plume continued with an extension of the coastal boundaries to conform to those of the existing fine grid model in the southern Strait of Georgia and the use of full mixed tides. Field work, using the Canadian Hydrographic Survey Launch *Brisk* included STD and current measurements in the region of the shallow banks around the river mouth and time series observations at an anchor station located in the central region of the plume. This is a joint project with J. Stronach and P. LeBlond of the Institute of Oceanography, UBC.

Preparatory to extending these studies to other aspects of the estuarine circulation, a program was developed which will specify the complete indexing system for three-dimensional calculations from an existing schematized coastline and mesh depths as employed in a conventional vertically integrated two-dimensional model. Sensitivity trials are proceeding with a laterally-integrated two-dimensional scheme (vertical and horizontal space dimensions) to examine the adjustments of coefficients required to give realistic longitudinal distributions of scalar and vector properties through Juan de Fuca Strait and the Strait of Georgia.

Joint field programs associated with these numerical model studies involved the verification of a large (5-10 km) eddy which was predicted by the model to form on a flooding tide at the southern end of Haro Strait. Confirmation was also obtained of the existence of comparable eddies in the vicinity of Race Rocks and East Point (with S. Huggett and J. Gower). These eddies are located along the major route seaward for fresh water discharge entering the Strait of Georgia from the Fraser River and are associated with strong local residual circulations. A further program with S. Huggett and R. Thomson, involved two one-week cruises in which time series patterns of CSTD profiles were obtained in the vicinity of an array of five current meter moorings located in the deep channel at the southern end of the Strait of Georgia. The important aim in this work is to provide data which will be used in the design of subsequent numerical calculations, involving deep salt water intrusions. (Crean).

A numerical model of barotropic tides in the channel system forming the approaches to Kitimat was carried out under contract, with Numerical Modelling staff advising on data analysis and modelling techniques.

Investigation continued into the feasibility of including negative eddy viscosity in a barotropic ocean circulation model in order to simulate the transfer of energy to barotropic motion from baroclinic processes.

Internal Kelvin waves in a narrow fjord have been modelled successfully using a new open-boundary technique which permits driving a model by incoming travelling waves. Substantial effort has been put into new numerical methods, in particular, extension of the above travelling-wave driving to more general two-dimensional long-wave problems. (Henry).

A one-dimensional two-layer model is under development for study of the conditions producing internal hydraulic jumps at fjord sills during tidal inflow and outflow. This work has been undertaken in conjunction with the investigation by Coastal Zone Oceanography Section of the dynamics of fjord circulation. Some special features of these models attempted the inclusion of the non-hydrostatic pressure field and the possible use of density as the vertical coordinate. The models will be compared with data taken by the Coastal Oceanography Section in Babine Lake, Knight Inlet and in laboratory experiments.

Two different analytical models were used to simulate the water waves in Kitimat Inlet due to the submarine slide of 27 April 1975. This work is in support of the activities of the tides and water levels group. Scientific direction of two modelling projects sponsored by Petrocan in connection with the Baffin Bay study was undertaken. One is concerned with wind-driven circulation in Lancaster Sound, the other with tidal motion in Baffin Bay. (Murty).

REMOTE SENSING SECTION

J.F.R. Gower - Head

J. S. Wallace

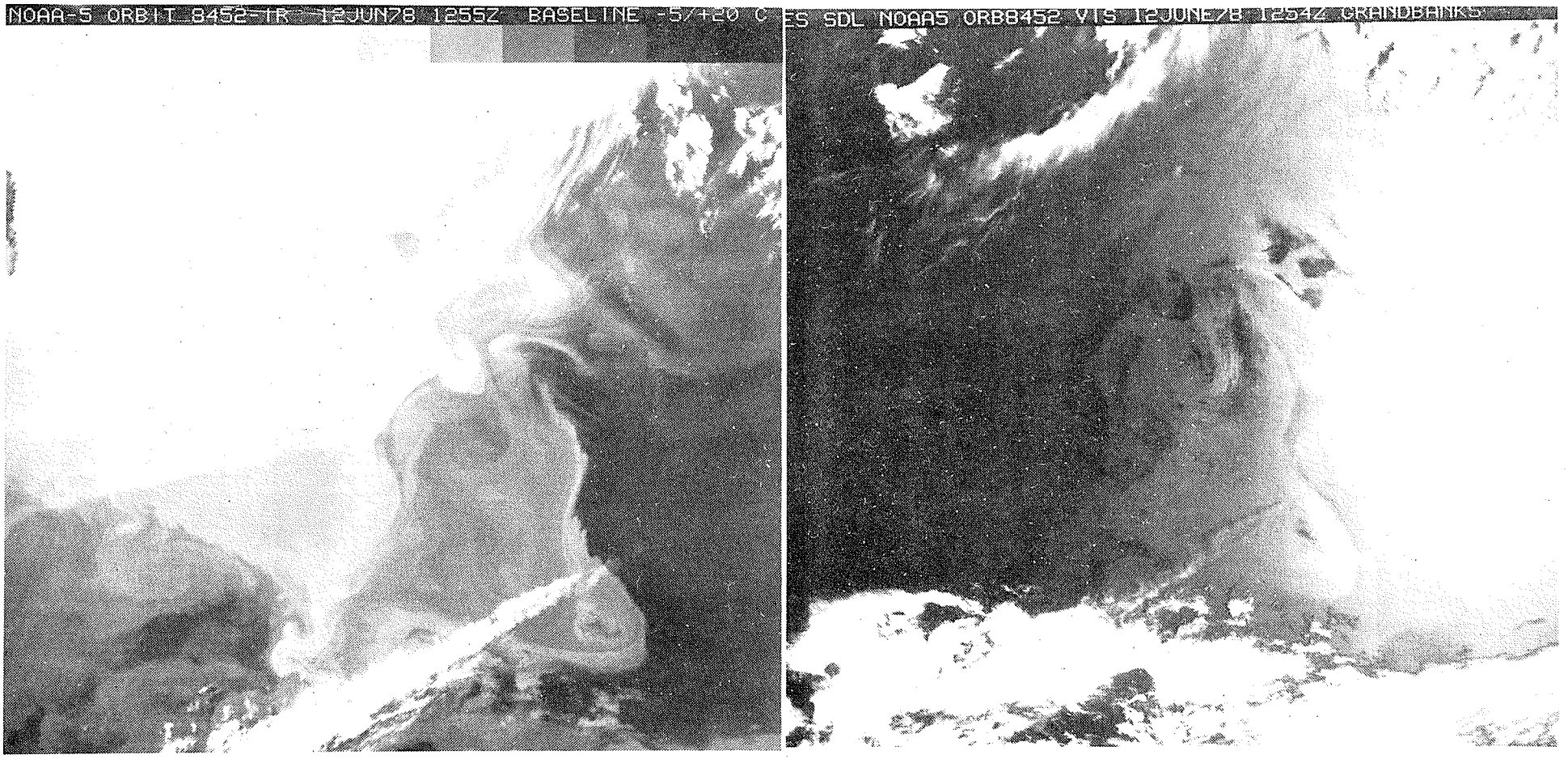
The remote sensing section has responsibility for development of remote sensing techniques for oceanography and for evaluation of techniques originating elsewhere.

During 1978 the international focus for oceanographic remote sensing was on two U.S. satellites due to be launched during the summer months. One, SEASAT would carry 4 microwave instruments designed to map sea surface wave patterns, surface winds, temperature and geoid level. The other, Nimbus G, would carry a water colour scanner designed to measure the near surface plankton concentration. The measurements would in some cases be only approximate, and in other cases be averages over large areas, but the world wide coverage provided by these satellites promised an interesting change in our view of the world.

The launch of Nimbus G increased worldwide interest in water colour mapping. Since 1975, the Remote Sensing Section at the Institute has been making airborne measurements of water colour of the same kind that Nimbus G now makes from space. Our work has concentrated on local water properties with the purpose of mapping primary productivity in coastal inlets and over the continental shelf. At an international colloquium hosted by the section at the Institute in June, our work and that of groups from Europe and the U.S. were compared. Our results stood up well to the test, and the fluorescence measurements that we had been concentrating on attracted considerable attention. A report on the discussions at the colloquium, which also covered a variety of other topics under the title "Passive Radiometry of the Ocean" is available as an Institute report.

Further water colour measurements were taken during 1978 and compared with simultaneous ship determinations of chlorophyll profiles in the water to extend our knowledge and experience of B.C. coastal waters. Properties of the fluorescent emission were studied in high chlorophyll levels achieved by growing a plankton bloom or "red tide" in a large open air tank at the Institute. Next summer we hope to extend the work with repeated surveys off the continental shelf and with an Arctic experiment in Lancaster Sound. Both these areas will be covered by Nimbus G at the same time from space.

Several teams of scientists have been organized by NASA to conduct experiments on the accuracy of usefulness of the SEASAT-A instruments. J.F.R. Gower is a member of the Synthetic Aperture Radar team and is involved in an experiment to use this instrument for mapping of coastal B.C. waters looking, in particular, at surface effects of internal wave patterns. The

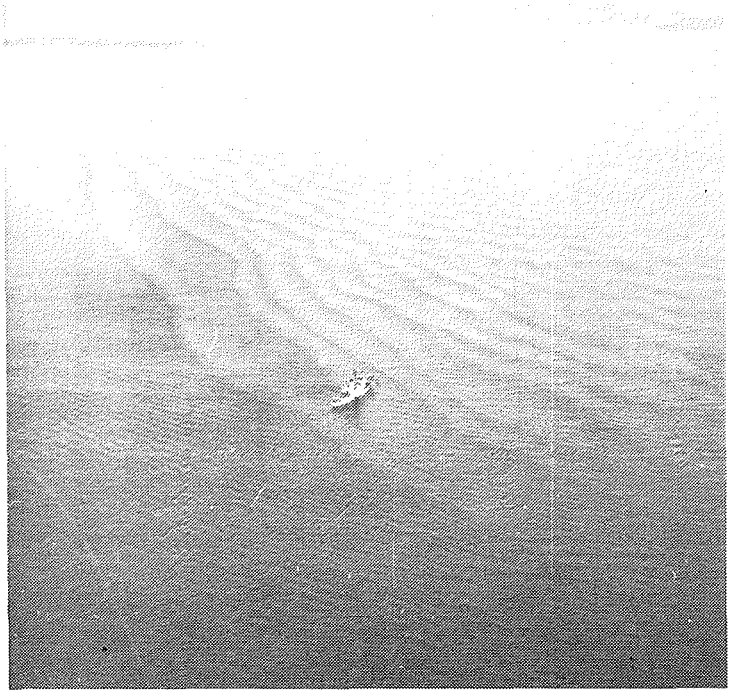


A B

A pair of satellite images taken at the same time by the NOAA weather satellite, NOAA5. A, the thermal infrared, maps water temperatures and shows a tongue of cold water extending down into the Gulf Stream. B, the visible, shows reflected sunlight (sunglint) which indicates roughness changes in the cold and the warm water. The Remote Sensing section at IOS is involved in an experiment to map these variations with the SEASAT orbiting radar.

internal waves produce characteristic bands of roughened water whose slopes were measured using a laser instrument mounted on the research vessel *Endeavour* . This experiment is designed to test theories of radar imagery as well as to study the waves and their movements. We are also involved in an experiment to map the structure of the Gulf Stream looking at surface effects induced by the thermal or dynamic properties of the current. The Gulf Stream causes roughness variations by heating the lower (boundary) layer of the atmosphere and also by deflecting surface waves along the current boundary. Roughness variations over the current have been seen in sunglint recorded by U.S. NOAA weather satellites. Although the satellite has now stopped working (due to a failure in the slip rings which carry power from the solar panels) radar data was collected over both experiment test sites. The data needs complicated processing and has still not been released, but other types of pictures of the patterns being studied are included in this report.

Other projects undertaken by the Remote Sensing section include surface current mapping by tracking drogues from an aircraft equipped with an inertial navigation system. Several such flights were made as part of a test of new low frequency coherent radar designed to map surface currents over a large area. Preliminary tests were also made on possible oceanographic uses of the new coast guard vehicle traffic management system which consists of a network of radar stations covering the approaches to Vancouver and Victoria.



An airphoto of the research vessel "Endeavour" making measurements of an internal wave packet in Georgia Strait. Airborne and satellite images taken at the same time will be used to test theories of the radar imagery process and to evaluate the radar for future oceanographic programs.

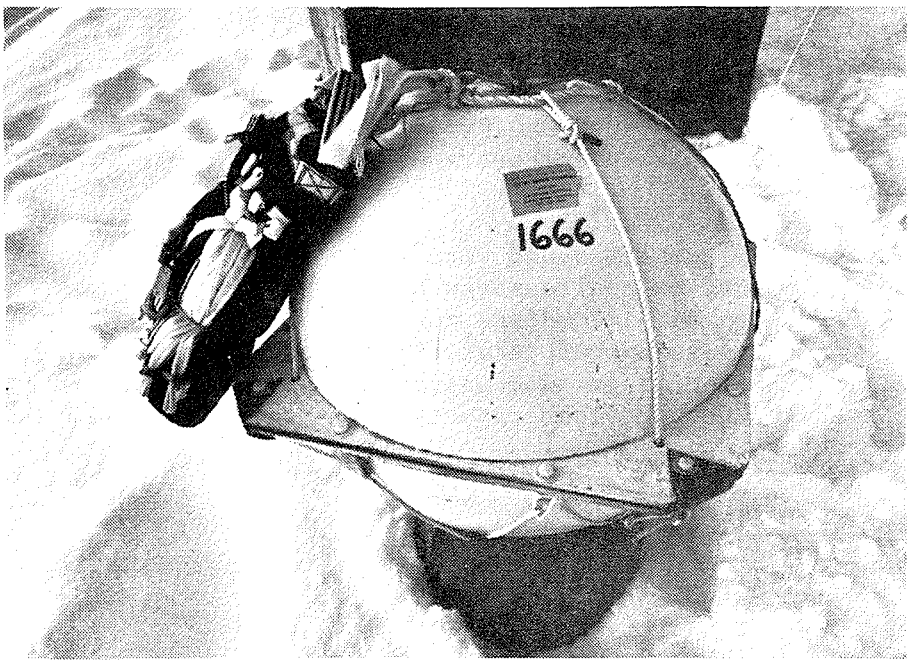
ARCTIC MARINE SCIENCE

A. R. Milne - Head

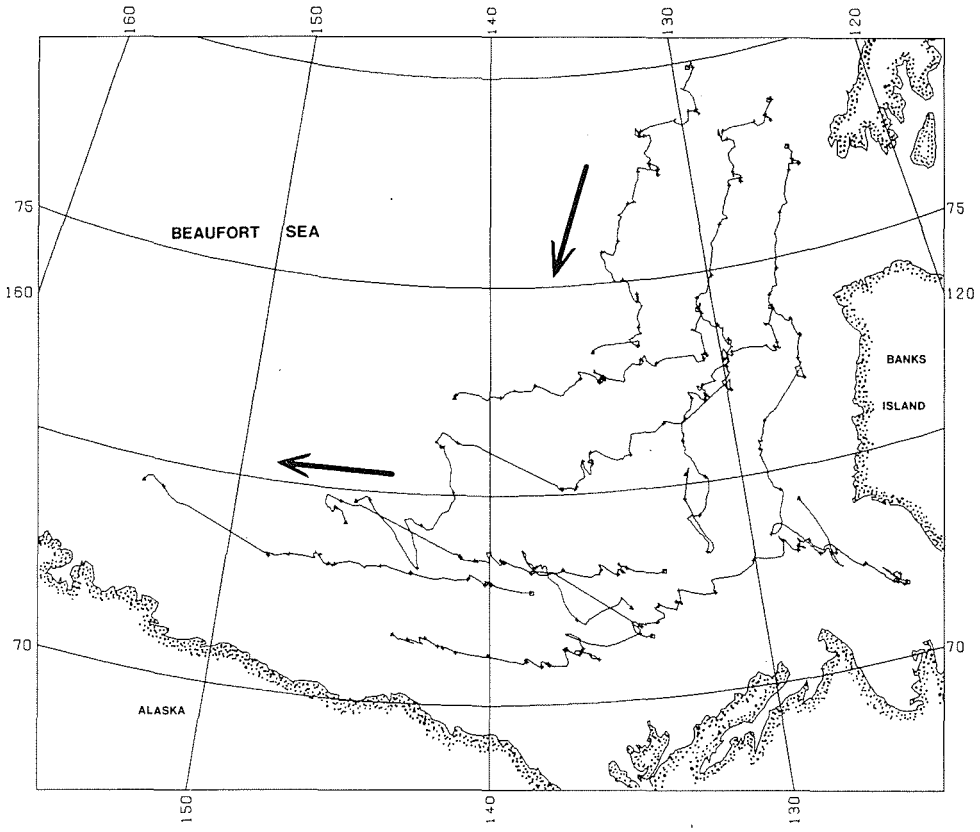
B. D. Smiley H. Melling (Postdoctoral Fellow) R. H. Herlinveaux

The Beaufort Sea and Parry Channel were our geographic focus of interest during 1978. The joint "government/industry" Beaufort Sea Project continues to distribute technical and environmental information through the Institute library. Three of the projected six Overview Reports have been published for general readership; the remainder - in various stages of drafting and editing - will be published before the Project's close-down date in mid-year, 1979. Other research activities of the group concerned problems of proposed industrial development of offshore gas and oil.

In January and early March, 1978, fifteen Random-Access Measurement System Data Buoys were air-dropped on to the offshore Beaufort Sea ice. Throughout the winter, they transmitted positions to the NIMBUS-6 satellite until, one by one, the buoys ceased reporting as a result of being crushed by ice or through failure. One exceptionally durable buoy operated until late October having travelled about 800 km on an erratic path from Banks Island to a position near Point Barrow, Alaska. Two of the buoys carried air-pressure sensors which, together with NOAA satellite imagery, will aid the interpretation of Beaufort Sea ice drift. This study has nicely verified the speculated clockwise drift of the offshore pack ice, at speeds of up to 1.5 km/hour. A major study addressed the environmental hazards of offshore drilling in Lancaster Sound. The subsequent report (which stressed the hazards of icebergs and strong currents to drillships, as well as the threat to the marine wildlife from oil pollution), has assisted the Department of Indian and Northern Affairs and the Federal Environmental Assessment Review Panel in judging the acceptability of the application by Norlands Petroleum to drill exploratory wells.



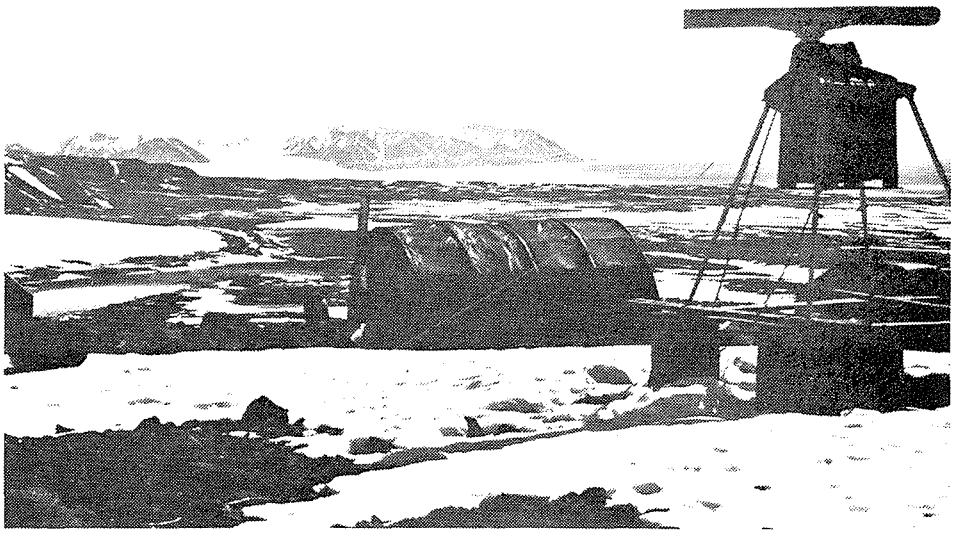
Random-Access Measurement System (RAMS) Data Buoy readied for air-dropping.



RAMS Data Buoy movements from 15 January to 11 September 1978

A second proposed study reviewed the environmental hazards of the year-round transport of liquid natural gas, by icebreaker, through Parry Channel. The novelty of this industrial endeavour (called the Arctic Pilot Project) taxes our ability to make even rough predictions of impact to resident and migrant seabirds, seals, polar bears and whales. The report will be published in early 1979.

Icebergs in eastern Lancaster Sound were followed by radar atop the 450 metre-high Hope Monument, on southeastern Devon Island. This cooperative study with Petro Canada Limited was conducted by Seakem Oceanography Limited. Their finds indicate that, from early July to late September, the general circulation of surface waters sweeps ice and icebergs from Baffin Bay into Lancaster Sound. Icebergs commonly travel at speeds of 1.1 km/hour in offshore waters.



Radar Camp at Hope Mountain

There were disappointments in 1978 involving the measurement of ocean currents in Parry Channel. We were unable to recover three over-wintered moorings of current meters from the 700 m deep waters of eastern Lancaster Sound. The unsuccessful instrument recovery, resulting from the apparent failure of the acoustic releases, was compounded by late ice break-up and heavily ice-infested waters which hindered the M.V. *Theron,* a Petro Canada charter vessel. Later, under contract to Dobrocky Seatech Limited, we attempted to deploy three overwintering moorings of current meters on the Barrow Sill, north of Somerset Island. Specially designed taut-wire, torsionally-rigid moorings were used in order to compensate for the near-zero magnetic field in this area of the Arctic. Even with Canada's newest icebreaker CCG *Pierre Radisson* serving as the deployment ship, severe ice conditions prevented access to the Sill area. At an alternative location, the near-surface floats attached to the moorings imploded, and the program was aborted. Surprisingly, the imploded floats were improved re-designed substitutes for the aluminum floats which had failed in pre-program testing.

Members of this group often served as advisers to industry and other Government agencies. Advisory tasks included the measurement of water/gas flows in leaking sub-sea wells in the Beaufort Sea, participation in public hearings on offshore drilling in Lancaster Sound, review of the Polar Gas Project and Davis Strait drilling program, management of the Arctic Ocean Dumping program, review of the Arctic Marine Oilspill Program (Environmental Protection Service), management of the Beaufort Sea Contingency Planning Task Force, and the Beaufort Sea Scientific Response Plan. Such roles are not likely to decrease with the current burgeoning of offshore industrial activity in Arctic Canada.

OCEAN CHEMISTRY DIVISION

C.S. Wong - Chief of Division

B. Mathias - Secretary

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

Visiting Scientists:

J. Hoff (IOUBC - NRC Fellowship)
K. Kremling (Institut für Meereskunde, Univ. of Kiel, F.R. Germany)
H. Peterssen (Institut für Meereskunde, Univ. of Kiel, F.R. Germany)
E. Bauerfeind (Institut für Meereskunde, Univ. of Kiel, F.R. Germany)
D. Cossa (Rimouski University, Quebec)
J. Piuze (Pêches et Sciences de la Mer, Québec)
R. Schmitt (Schmitt Consultants - F.R. Germany)
K. Vermeer (Canadian Wildlife Service)
B. Imber (Department of Oceanography, University of Liverpool, U.K.)

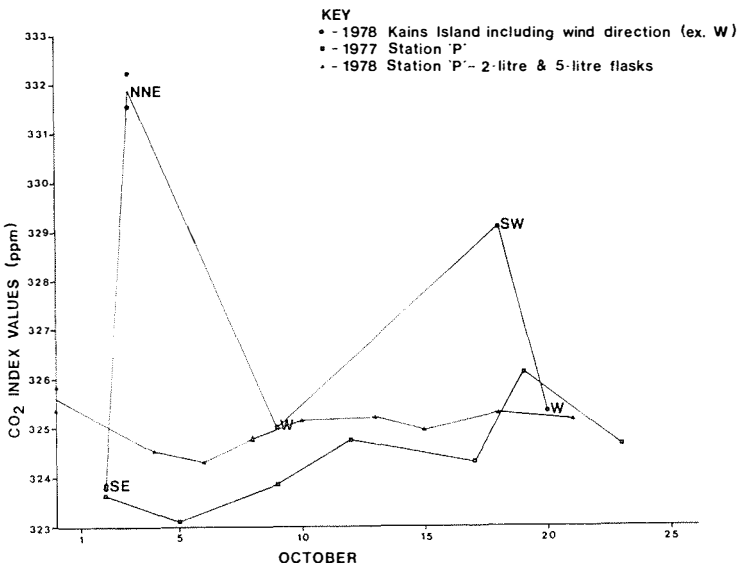
Ocean Chemistry Division's primary responsibility is to understand the chemical aspects of the marine environment in B.C. coastal waters, the western Arctic and N.E. Pacific Ocean and to assess the chemical effects of human activities on seawater, suspended matter and bottom sediments. These effects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

The Division is actively supporting the Federal Government's Make-or-Buy policy, with over 60% of our effort devoted to contract work. The goal is to assist in the establishment of a self-sustaining and credible capability in private industry to conduct chemical baseline studies in coastal waters, chemical environmental impact assessment and arctic facilities, including ultra-clean laboratories for trace metals and hydrocarbons, heavy isotope mass spectrometer for accurate trace metals measurements, gas chromatograph/mass spectrometer for organic work, and an infrared CO_2 laboratory for the carbon cycle. These facilities enable us to stay at the state-of-the-art of ocean chemistry, with sufficient scientific capability to supervise contracts, scrutinize work performed by the private sector and provide scientific advice to policy-makers in an effective way.

Marine Carbon Cycle

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

The question of atmospheric CO_2 increase and its possible climatic consequences is perceived as a future international problem. As mankind faces the challenges in the year 2000 with exciting new scientific and technological advances, he is also moving closer to a warning landmark in time, when the possible warming from CO_2 generated by fossil fuel burning may be significantly above the climatic noise level. The scientific community has the urgent challenge to understand the environmental behaviour of CO_2 and to predict reliably the future course of rise in CO_2 levels and an associated increase in atmospheric temperature within this short span of the next 21 years. The on-going research in Ocean Chemistry is contributing to this global international effort by providing insights into the marine aspects of the complex global carbon cycle.



Time series of CO_2 at Ocean Weather Station P and at the lighthouse on Amphitrite Point on western Vancouver Island, where onshore westerlies favour uncontaminated marine air samples.

The major emphasis of our approach is still on time-series measurements of CO_2 over the ocean. The CO_2 time-series at Ocean Weather Station P (50°N 145°W) is in the tenth year of documenting the increase in atmospheric CO_2. In response to a decision of the Canadian government to terminate the weatherships in the near future, replacement programs have been set up on a crash basis in order to have overlap and continuity between the weathership time-series data and the new data. Through cooperation with the Canadian Coast Guard and the Atmospheric Environment Service, weekly air samples were collected at lighthouses at Amphitrite Point and Kains Island on the west coast of Vancouver Island. Moreover, through the assistance of the Montreal Shipping Co. and the Canada Maru, air samples were collected between Victoria and Japan about once per month across the Pacific Ocean. Preliminary results indicated that during periods of onshore winds almost identical values were obtained at Amphitrite Point and at Ocean Weather Station P.

A more critical scrutiny of the contribution from wood burning to atmospheric CO_2 level indicated a smaller value than reported previously, but it still amounts to a significant fraction of about 15% of the present-day burning of coal, gas, petroleum and limestone. This revised lower figure was based on taking into account factors such as incomplete combustion and longer degradation time of buried stumps. The greater lack of present knowlege is determination of the role of detritus reservoirs of carbon both on land and at sea. Continuing work on marine detritus suggested that at Ocean Weather Station P, seasonal fluxes of detritus carbon from surface waters into deep ocean may be a significant mechanism in the carbon budget. Between the winter months (January) and the summer months (July), a four-fold increase of particulate organic carbon was observed at all depths between 0m and 1000m which can be attributed to increased summer productivity and a subsequent increase in particulate carbon transfer.

Considerable effort was devoted to preparation work for the First GARP Global Experiment cruise to the South Pacific in December, 1978. Joint work with Dr. Schmitt of F.R. Germany was supported by NATO for the development of a pCO_2 measuring device using this water-correcting infrared CO_2 analyzer and a seawater equilibration system. This was installed on the C.S.S. *Parizeau* to measure atmospheric and surface seawater pCO_2 continuously between Victoria and Hawaii, then along the cruise track at 155°W to the equatorial Pacific Ocean.

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

Steps are being taken to bring the radiocarbon facility on-line in order to process the backlog of Station P samples taken over the past several years.

Trace Metals

(Wong, Kremling, Peterssen, Imber, Piuze, Cossa, Johnson, R.W. Macdonald, D. Macdonald)

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

A serious gap in knowledge exists between marine chemists engaged in attaining meaningful levels of trace metals in seawater and those working on modelling of chemical speciation and biological effects of trace metals. The latter groups often select unrealistically high levels of trace metals based on literature values obtained prior to the availability of reliable techniques. To narrow this gap, Ocean Chemistry is carrying out a co-operative study with Dr. Kremling's group at the Institut für Meereskunde at Kiel, F.R. Germany and Professor Riley's group at Liverpool, U.K., on accurate measurement of trace metals in seawater, funded by NATO. An intercomparison of sampling devices and analytical techniques was carried out in August using a small CEPEX (Controlled Ecosystem Population Experiment) enclosure of 65,000 litres of seawater in Saanich Inlet, B.C.

The seawater collected was processed and analyzed in clean rooms. Preliminary results indicated the failure of commonly-used samplers to capture representative water samples at the desired depth. The results also suggested the availability of analytical methods of sufficient precision in the case of copper, nickel, lead and cobalt but not so for cadmium, mercury, iron and zinc. (Wong, Kremling, Johnson, Peterssen, Imber, Stukas, Berrang, Erickson, Thomas).

The ultra-clean laboratory specifically designed for ultra-trace metal work was put into operation about half a year after our move to Patricia Bay. This unique laboratory consists of three areas: entrance room, instrument room, and preparation and processing room. All are maintained under positive pressure with filtered air which has undergone 99.97% removal of 0.3 micron and larger sized particles. This unique facility is being utilized to develop accurate techniques for lead, mercury, cadmium and other trace metals in sea water and to develop "standard sea water" for trace metals representative of natural levels using Ocean Weather Station P sea water. This work is currently funded by NATO and possibly will cooperate later with the NRC Atlantic Region Laboratory. Recent work using a clean room showed that in Saanich Inlet and in the Strait of Georgia, total lead in sea water is of the order 20 ng kg^{-1} which is considerably less than levels obtained previously without using cleanroom techniques. (Stukas, Johnson, Wong).

Use of tetraethyl lead in gasoline has produced a serious environmental problem. Supported by Environmental Contaminants contract funds, the pathways, fate and behaviour of tetraethyl lead in the marine environment were investigated using three 65,000 litre C.E.P.E.X. enclosures spiked with 0, 5 and 50×10^{-9} of tetraethyl lead. The compound showed marked biological effects on the planktonic community, as indicated by a decrease in C-14 productivity, chlorophyll-a, drastically at the 50×10^{-9} level. However, natural processes quickly removed this compound from both sea water and particulates with the system reverting back to background concentration levels within 6-10 days. (Stukas, Wong).

Utilizing the most recent improvements in techniques to extract multi-elements from sea water based on the Danielsson method of University of Göteborg, long-term storage tests were carried out for sea water. With this improved method for mercury, the level of total mercury in Saanich Inlet was found to be extremely low at 5-6 ng kg^{-1} of seawater. (Johnson, Wong).

Knowledge of the rates of release and accumulation of trace metals is important to Ocean and Aquatic Sciences in managing the Ocean Dumping Control Act. In light of recent advances in both chemical methodology and marine chemical research Ocean Chemistry has initiated the first of a series of chemical studies to determine the validity of existing criteria regarding permissible maximum quantities and concentrations of toxic compounds in the dumped material presently specified under the Act. The first experiment was designed to examine the variability in analytical results on dredged spoils taken from Victoria Harbour and loaded on ocean dumping barges. Ambiguity in wording and loopholes in the Act were found. For example, mercury values from a small number of samples (two in this case) were within the present 0.75 mg kg^{-1} limit. However, the average obtained from analysis of 40 samples was 1.90 mg kg^{-1}, far in excess of the present limit. Study is underway to define the dimensions of the revision required for the regulations. Chemical variability of samples from the same dumping barge and

between different barges was also investigated. Statistical analyses indicated a small but distinct difference between pre-dredged samples and those from four barges, for analyses of copper, iron, lead, zinc, cadmium, chromium, mercury, arsenic, organic carbon and organic matter. To improve the effectiveness of regulations, a selective extraction scheme for trace metals from marine sediment and dumped material was designed and contract laboratory studies were carried out to test the scheme. We hope this may lead to a new set of ocean dumping criteria for assessing the impact of trace metals, based on accumulation and release rates. (R.W. Macdonald, Wong).

A C.E.P.E.X. experiment was conducted in July to study the oxygenation and removal rate of Mn(II) and Fe(II) under natural conditions. Copper and cadmium ions were added to investigate the removal of these trace metals on precipated manganese and iron-oxyhydrates. Preliminary field results indicated a very rapid rate of removal of iron and manganese from the water column within days of their addition rather than periods as long as weeks or months which had been indicated in previous laboratory experiments. (Kremling, Peterssen, Munro, Johnson, Wong).

Marine Hydrocarbons and PCBs

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

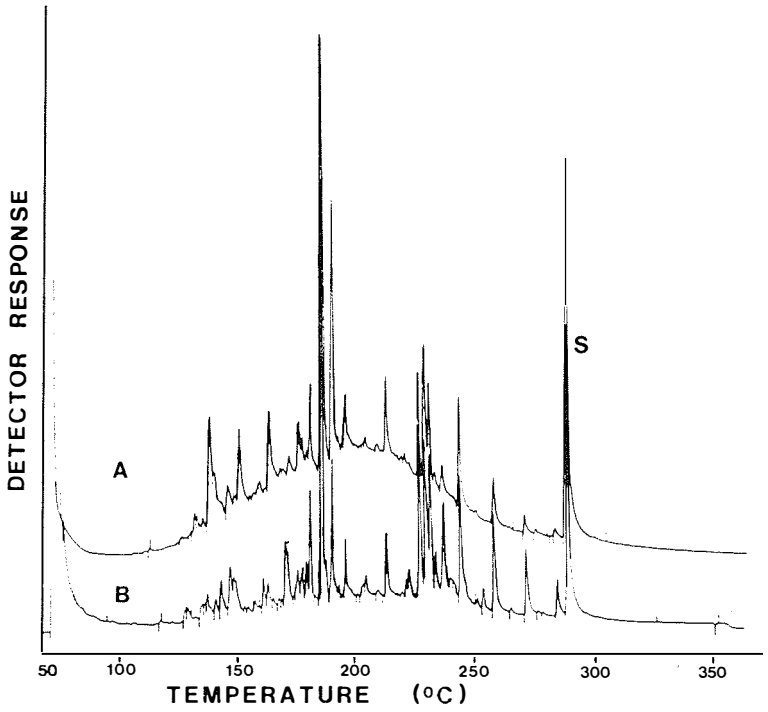
The objective of this program is to understand the occurrence, pathways, and fate of hydrocarbons (natural, petroleum, polychlorinated biphenyls and pesticides) in the marine environment. The main effort was devoted to a C.E.P.E.X. study of the behaviour of PCBs in the marine environment and to a Kitimat baseline study.

As in the case of trace metals, a unique clean room has been established for study of trace hydrocarbons. The clean room, consisting of entrance laboratory, instrument room with gas chromatographs, a gas chromatograph/mass spectrometer, and a high performance liquid chromatograph, and a preparation room, has 99.97% of particulates larger than 0.3 microns diameter removed by high efficiency filtration. Early in the year, joint work was performed with the NRC Atlantic Region Laboratory on a hydrocarbons sampler intercomparison study using a C.E.P.E.X. enclosure. (Cretney, McLaughlin).

PCBs, because of their persistence and toxicity in the environment, have been placed on the prohibited list of the Environmental Contaminants Act. Supported by Environmental Contaminants contract funds, a systematic study was carried out to understand the behaviour, pathways, residence time and sub-lethal toxic effects of PCBs in the marine environment using C.E.P.E.X. 65000 liter enclosures in Saanich Inlet, B.C. In August, 3 bags were launched and spiked with 0, 5 and 50×10^{-9} of PCBs (Monsanto Arochlor 1254) and observations were continued for 28 days. Preliminary results indicated that the overall effects of PCBs on phytoplankton were similar to those from other types of hydrocarbons, with the initial diatom population being replaced mainly by microflagellates. There was also a marked effect on the zooplankton population (Paracalanus parvus adults and copepodites mainly). PCBs were quickly removed as settling particulate material with 50% removal in 3-5 days and 90% removal in 10 days. Another PCBs study was carried out in connection with the Ocean Dumping Control Act. A contract was let to test the

statistical validity of permitting the use of only the "usual" small number of PCBs analyses now performed to satisfy a permit application, against requiring the average of a large number of measurements on the same batch of samples. Preliminary results indicated the PCBs measurements were highly variable. (Macdonald, Wong, Cretney, Bauerfeind).

Coastal waters in northwestern B.C. are within a region where high industrial growth is expected in future. There has been serious environmental controversy regarding the siting of an oil port at Kitimat to receive Alaska crude shipments. A terminal for shipping Alberta wheat to China was proposed recently for Prince Rupert. Ocean Chemistry is supervising a contract basline study in this environmentally sensitive area. Two chemical oceanographic cruises were conducted in the Kitimat Harbour, Douglas Channel and approaches: one June 19-29, and another October 18-27. Standard chemical oceanographic stations (T, S, O_2, nutrients, and CTD casts) were carried out together with Neuston-net tows for debris and tarballs, SCOR-net tows for plankton, surface sediment sampling for lead-210 dating and hydrocarbons, trace metals analyses, and the collection of intertidal mussels for hydrocarbon study. Preliminary results indicated very high concentrations of polyaromatic hydrocarbons in the sediment near the north side of the Kitimat Harbour (up to 1 mg kg^{-1} of pyrene), possibly due to production of flurocarbons during the electrolysis process in aluminum production. This difference in polyaromatics by one to two orders of magnitude between sediments from the approaches and the Kitimat Harbour itself may be a matter of serious concern. Further work is being done to assess the contribution of polyaromatics to carcinoma in the mussel, Mytilus edulis. (Wong, Cretney, Macdonald, McLaughlin).



Gas chromatograms of non-polar hydrocarbons in sediments from Kitimat Harbour (A) and nearby Kildala Arm (B). The pronounced "hump" in A is characteristic of hydrocarbon pollution.
S = internal standard.

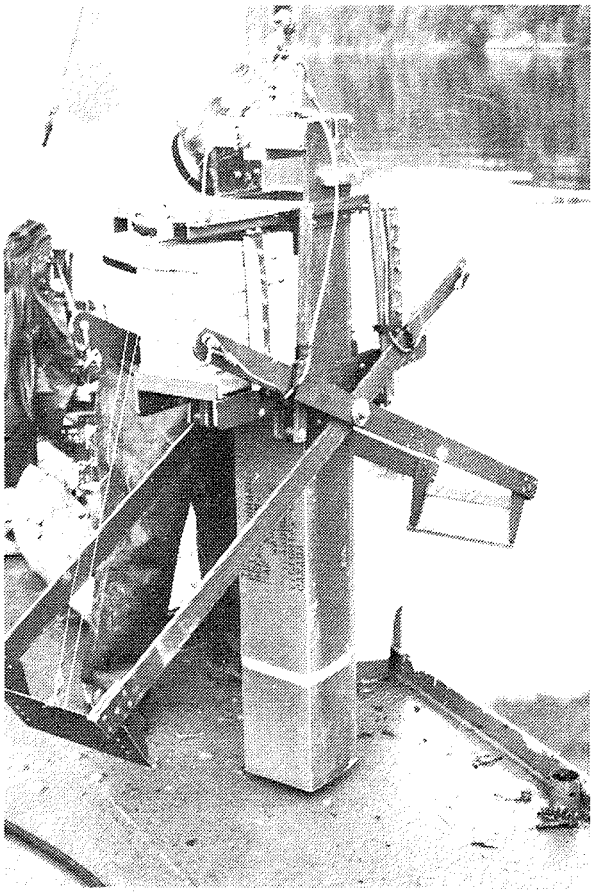
Cooperative work was carried out with Dr. Vermeer's group at Canada Wildlife Service to study tarballs washed up on beaches at Triangle Island situated at the northern tip of Vancouver Island. There may be reason for concern if the tar was derived from increased tanker traffic. However, preliminary hydrocarbon analyses indicated the origin of the tar to be from bilges rather than from crude oil of the Alaska type. (Wong, Cretney, Vermeer).

Coastal Pollution

(Thompson, Paton, Hoff)

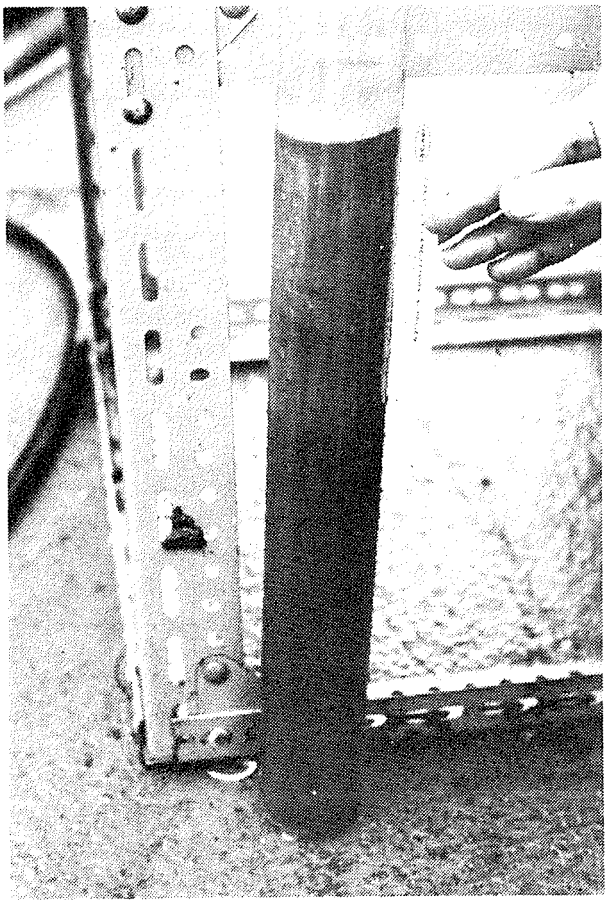
Mining is one of major industries in B.C. Its tailings disposal is of great concern to the environment departments of the provincial and federal governments. Recently, public hearings were held on the environmental impact of mine tailings disposal from copper and lead ores into B.C. coastal fjords and on the issue of re-opening of old B.C. molybdenum mines in future.

Joint work was conducted with EPS in waters off northern Vancouver Island to monitor the environmental effects of mine tailings. During the month of September, a joint cruise was carried out in the Rupert, Holberg and Quatsino area to collect sediment samples and pore waters, arsenic methylation samples and samples for tailings distribution. An in-situ experiment was initiated with EPS to utilize M. edulis, a mussel commonly found along the coasts, as an indicator of particulate copper uptake in the Rupert Inlet.



Box corer being prepared for cast - Rupert Inlet, September 1978.

Another nine-day cruise was conducted in mid-October to collect sediment samples for study of the methylation of lead and to collect core samples in Alice Arm and Hastings Arm for tailings distribution studies. Some analytical work was done to determine the copper and zinc distribution in sediment cores from Rupert and Holberg Inlets and for earlier cores in 1975 from Texada Mine. The Texada Mine tailings showed clearly defined dispersion and had the highest copper content observed so far in tailings analyses, at a concentration of 1600 mg copper kg^{-1} of sediment. (Thompson, Paton; Goyette of EPS)



Sediment Tailings Interface - Rupert Inlet, September 1978

To determine the extent of methylation of metals occurring in marine sediments, studies were conducted in the Alice Arm area by contract on methylation of arsenic (funded under the Environmental Contaminants Act) in the Alice Arm area on methylation of lead (supported by Ocean Dumping funds) and in the Howe Sound and Port Alberni area on methylation of mercury (also supported by Ocean Dumping funds). The production of methyl mercury appeared to be as great as that detected in the Port Alberni sediment despite higher organic loadings there. Methyl mercury was degraded at a much more rapid rate than anticipated in marine sediments. Rates of demethylation are temperature dependent. It appears that organisms responsible for demethylation are less efficient at lower temperatures relative to methylating organisms. (Thompson, Paton).

In August, a two-day cruise was undertaken to collect benthic samples at the Macaulay Point outfall, a relatively polluted area, and at Clover Point, where background environmental data should be collected prior to completion of the sewer line extension into deeper waters. (Thompson, Paton).

Laboratory study was initiated on the release of trace metals from mine tailings in sea water, using a multi-element extraction technique modified from Danielsen's method for copper, zinc, lead, cadmium, iron, nickel, cobalt and manganese. (Hoff, Thompson, Wong).

Amundsen Gulf

Ocean Chemistry Division participated in the C.S.S. *Parizeau* Amundsen Gulf cruise on a ship-of-opportunity basis, to collect sea water samples and surface sediments. Due to unfavourable ice condition and a tight schedule, only three stations were occupied out of ten planned. (D. Macdonald, R.W. Macdonald).

Weathership Program

Open-ocean effort was devoted to a continuing study of the long-term trends of chemical parameters at Ocean Weather Station P (50^{o}N, 145^{o}W). Neuston-net tows were made between Victoria and Station P to collect tarballs and other surface pollutants. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon were taken together with some continuous shipboard infrared measurements of marine air CO_2 and pCO_2. Samples of nutrients were taken to provide information about long term fluctuations and their relationship to circulation and the marine food chain. Particulate detritus organic carbon samples were collected on the *Quadra* cruises. An examination of storage techniques for nutrients was initiated by collecting large water samples in a variety of locations. Multiple replicate runs onboard ship allowed accurate determination of the nutrient concentrations and the precision of the automated analysis. The effect of filtering, quick or slow freezing and storage time is currently under investigation by analyzing portions of batched samples at various time intervals. (Bellegay, Wong, R.W. Macdonald, McLaughlin).

OCEAN ECOLOGY LABORATORY

R.O. Brinkhurst - Head

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

+Joined during 1978

This year the laboratory gained two new positions which have been filled by Steve Hill and Dave Mackas. Grant Gardner stayed on under contract at the end of his fellowship to complete his zooplankton studies.

Lengthy negotiations on the ship-of-opportunity segment of the Pelagic Ecosystem Prediction project were successfully completed with the award of an unsolicited proposal contract to Seakem Oceanography. Six cruises on a track between Howe Sound and Tahsis Inlet will be conducted during the early part of 1979 using a duplicate plankton sampler of the type developed by Dave Mackas. We will be cooperating with the Remote Sensing Section for airborne surveillance of various parameters on either side of the ship track. We have also spent considerable time assembling equipment and planning our in-house research contribution to the project via cooperative studies on the shelf with Hydrography and Ocean Physics. The pilot project for the ship-of-opportunity study using the Imperial Oil tankers is underway, funded by Dr. T.R. Parsons (IOUBC) and housed at the Institute.

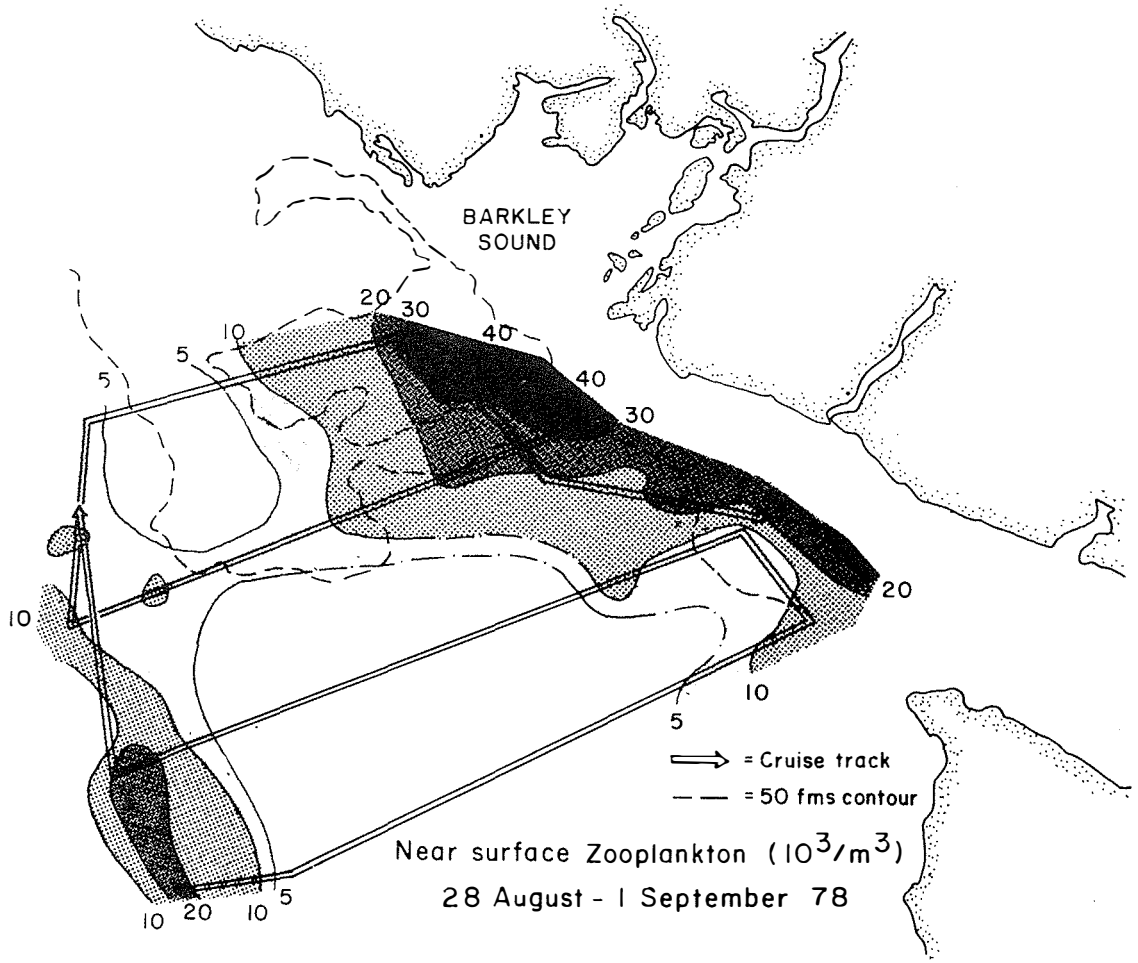
Another unsolicited proposal has resulted in a contract being signed with T. Beak and Co. in Toronto to test theories related to the activity of sludge worms in churning sediments and returning heavy metals to the environment when they might otherwise have remained buried.

The laboratory provided the largest part of the organization of the American Society of Limnology and Oceanography summer meeting in Victoria which was co-hosted by the Institute of Ocean Sciences and the University of Victoria. About 800 people enjoyed good weather, good company and stimulating science and the meeting has been acknowledged as a success. It certainly helped to publicize the work of the Institute, especially in the biological community.

During 1978, our work was assisted by a variety of people working under F.L.I.P. (Federal Labour Intensive Program) summer student positions and under contract.

Dr. Brinkhurst continued to administer the OAS, Pacific Region contribution to the Ocean Dumping program, looking after the review of dumping applications, the reporting work involved and supervision of the research contracts with the help of Bob Smith, the Institute Industrial Liaison Officer.

Dr. D. Mackas led a series of cruises in B.C. coastal waters designed to locate, map, and explore the biological and physical dynamics of various regions of high plankton production and standing stock. The cruises concentrated on continuous underway sampling using Ocean Ecology's automated plankton counting system. The areas surveyed were Georgia Strait (May, July), the continental shelf south and west of Barkley Sound (August), and Queen Charlotte Sound and the mainland inlets (October cruise led by Dr. Gardner). Strong plankton aggregations were found, typically forming a banded pattern oriented parallel to the local bathymetry. Mackas was also involved with organization of the Victoria ASLO meetings, and presented results of his 1977 work from the Canada-Peru ICANE project.



Plot of Zooplankton Distribution off B.C. Coast From the Mackas Counter

Dr. G. Gardner's survey of British Columbia coastal marine zooplankton is progressing well. The last of four major cruises was completed in October, and data from the whole set of cruises are now being analyzed. A preliminary analysis of the whole data set, and a more complete analysis of the data from the first two cruises, will be completed by the end of the fiscal year 78/79. To date, the sampling areas have been subdivided into regions defined by similar temperature/salinity characteristics. To a large extent the same station groupings have been derived from the observed species distribution patterns. This supports the assumption that physically definable regions can be characterized by unique assemblages of zooplankton. This information is important to our understanding of the mechanisms by which different zooplankton communities are formed and maintained. Such information regarding large scale variations in zooplankton community composition can be of considerable use to studies of the production of salmon and other commercially important species. (Mackas, Gardner).

In cooperation with Terry Curran of Institute Electronics, Ocean Ecology has developed a vertical profiling instrument system to complement the continuous flow-through instrumentation used by Dr. Mackas for horizontal mapping. When completed the package will include a conductivity-temperature-depth (CTD) probe, a rosette bottle sampler, an in-situ fluorometer, a beam transmissometer and a dissolved oxygen meter. We have also acquired a desk-top computer for both logging and near real time graphical display of the data.

The new system is to be used on the west side of Vancouver Island during the cooperative study of the continental shelf waters to be jointly conducted in 1979 by Ocean Ecology, Ocean Physics, and Tides and Currents. It will allow us to sample the fine scale vertical structure of several variables as the instrument is lowered through the water. Based on the observed structure, the rosette bottles will be tripped at the desired depths as the instrument is raised back to the surface. The water from the bottles will be used for phytoplankton identification, nutrient analyses, routine chlorophyll, salinity and oxygen calibrations. The data will be used to study the effect of vertical and horizontal transport of nutrients and phytoplankton on the productivity of the phytoplankton and zooplankton. (Denman, Hill).

In benthos studies, Peter Chapman finished his field study of the North Arm of the Fraser River. Results show salinity in the sediments changes seasonally but not daily despite the diurnal changes in the water column due to tides. The benthos moves alternately seaward and landward during the year in response to the dominant annual flow pattern of the river.

The distribution of aquatic oligochaetes (sludge worms) is under continuous review based upon observations in both local coastal localities and on a world-wide basis as collections are made available. The explosion of knowledge on marine species has led to active collaboration with a number of colleagues which will culminate in the first International Symposium on Aquatic Oligochaete Biology to be held at the Institute in 1979. Planning for this has been totally in the hands of Ralph Brinkhurst for a year or more.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

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

D.A. Doyle - Secretary

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1978 hydrographic and scientific programs and for several federal departments and universities.

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

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

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

CSS *WM. J. STEWART* (65 m, 1920 tonnes)

Decommissioned and scheduled for disposal.

CSS *VECTOR* (39.6 m, 505 tonnes)

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

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

CSS *RICHARDSON* (19.8 m, 78 tonnes)

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

Richardson continued sidescan sonar programs with Pacific Geoscience Centre, oceanographic survey with Ocean Chemistry, oceanographic survey with U.B.C., search and rescue duties, and fishery patrol duties.

M.V. *RADIUM EXPRESS* (22.2 m, 100 tonnes) on charter

Master: Wm. Kirkland Chief Engineer: F. Bogart

Continued Mackenzie River and Mackenzie Bay hydrographic surveys.

M.V. *PANDORA II* (58.2 m, 1220 tonnes) on charter

Master: R.A. Jones Chief Engineer: C. Tuck
I.A. Sturgess

Pandora II with *Pisces IV* were employed in the following programs: for Ocean and Aquatic Sciences, Ocean Mixing and Ocean Ecology; for Defence Research Establishment Pacific, Acoustic and Flow Noise trials; for Environmental Protection Service, examination of mine dumpsites; and for Pacific Geoscience Centre, Geology off the northwest coast of Vancouver Island; *Pandora II* herself conducted three months of hydrographic survey in the Amundsen Gulf.

PISCES IV (6.1 m, 12 tonnes)

Chief Pilot: I. Sanderson

Pisces IV, a deep diving subermsible, was engaged in a geological survey of the Continental Shelf, investigation of ocean mixing at the edge of the Fraser River plume, investigation of mine tailings for the Environmental Protection Service, recovery of tidal survey meters and pilot training. She is scheduled for major modification early in 1979.

CSL *REVISOR* (11 m, 10 tonnes)

The launch *Revisor* was used in support of coastal oceanographic programs and acoustic experiments.

LAUNCHES

Survey launches were employed by shore-based hydrographic parties working in the Strait of Georgia, Alberni Inlet and the Mackenzie River.

DEPOT

The depot workshops continue to provide full support to all Institute activities.

MANAGEMENT SERVICES DIVISION

N. A. Todd - Chief of Management Services

Todd, N.A.	- Chief of Division
Aanhout, D.L. van	- Secretary, Regional Hydrographer
*Clarke, B.E.	- Secretary, F.S.R.G., Coastal and Offshore Oceanography
Coldwell, J.H.	- Stores
Cotter, M.L.	
Craton, M.I.K.	
Crouch, R.W.	- Purchasing
Curtis, J.N.	
Deane, G.J.	
Doyle, D.A.	- Secretary, Regional Marine Superintendent
Drysdale, A.E.	
Hall, E.J.	
Harbar, M.S.	
Jones, K.M.G.	- Secretary, Chief, Management Services
*Kwiatkowski, B.S.	
Lapp, B.I.	
Lohrmann, B.A.	- Administrative Services
Mathias, A.L.	- Secretary, Ocean Chemistry
McKenzie, S.D.	- Secretary, Regional Oceanographer
Miles, M.L.	
Parsons, J.E.	- Finance
Peirson, E.	- Secretary, F.S.R.G., Coastal and Offshore Oceanography
*Powers, M.A.	- Secretary, Ocean Chemistry
*Raine, G.M.	- Secretary, F.S.R.G., Coastal and Offshore Oceanography
Reinstein, H.G.	- Facilities Operation and Maintenance
Sabourin, J.T.	
Smith, R.M.	
Thomas, C.D.	- Central Registry
van Dusen, T.S.	- Secretary, Director-General

*Left during 1978

Commissionaires

Sgt. D.W. Price	Comm. E. Hawkings
Sgt. W.L. Caldwell	Comm. H. Moffat
Comm. G. Bradshaw	Comm. A. Samouelle
Comm. J. Gessner	Comm. C. Taylor
Comm. G. Glass	Comm. L. Trerice

Institute of Ocean Sciences - Construction

The long awaited occasion when all units forming the Institute of Ocean Sciences came together on one site occurred early in 1978.

Ocean Chemistry moved into their new wing in January and quickly became operational. With this move all of the premises at Harbour Road in Victoria were vacated. These premises are now being used by the Ministry of Transport.

The Department of Energy, Mines and Resources occupied their new offices and laboratories during the early spring months. Units of the Earth Physics Branch and the Geological Survey of Canada are located in the Institute and collectively are now known as the Pacific Geoscience Centre.

With the execption of a very few contracts, all construction work has now been completed. CANA Construction, who acted as Construction Managers for the project, turned over the management of the outstanding work to the Department of Public Works in June. A large part of the work since this date has been concerned with clearing up deficiencies and having corrective action taken under warranty.

Our experience so far indicates that the original design concepts inherent in the architectural brief have been satisfactorily realized and the physical facilities and layout are conducive to the achievement of our program objectives.

The large number of people visiting and touring the Institute during 1978 (approximately 2100 took conducted tours) indicates that the public is highly interested in the work being carried out at the Institute. It was also reassuring to hear many complimentary expressions from the local public on the presence of the Institute and its perceived significance, regionally and nationally.

Administration

The anticipated increased workload of getting the new facilities "on line" and of operating and maintaining them became a reality in 1978. At times it became almost the normal state to perform in a reactive mode to crisis situations. By and large, the staff was able to overcome these situations; and with some indication that we may be able to achieve a better balance between workload and resources we look forward to being able to operate in 1979 in a more even manner.

The financial, purchasing and materiel management, records management and administrative support components all felt the pressures of meeting increasing demands on them. These demands increased due to the general climate in government of greater administrative control, to implementing the terms of our cost-sharing agreement with the Pacific Geoscience Centre, to two full aduits -- one by the Auditor General and one by Audit Services Bureau -- and to some extent with the setting up of the new Department of Fisheries and Oceans. The latter may bring some relief as it appears the regional administrative offices will be allocated some manyears for 1979.

Further refinements were made in our Financial and our Manyear Reporting Systems and continued progress was made with the Inventory System. A Safety Committee has been organized and is functioning.

Changes in staff have perhaps been a little higher than normal. This was to be expected as staff adjusted to the change in the location.

Director General's Office

For the purposes of financial administration the Office of the Director General comes under Management Services. In an agency where the operational demands of scientists and hydrographers are naturally paramount, and administrative support staff are viewed as not always necessary evils, one welcomes opportunities to report on the scientific activities of members of one's group -- in this case the Director General.

In this last year Dr. Stewart not only had his usual clutch of book reviews, referee's reports, editor's remarks and research grant referrals to deal with, but he wrote a sizeable article on "Ocean Currents" for MacMillan's Merit Students Encyclopedia, one for the fall '78 issue of Oceanus on "The Role of Sea Ice and Climate" and one for Atmosphere-Ocean on "The Oceans, the Climate and People - With a View from Mars". In addition, he has finally completed a small book for the World Meteorological Organization on the Atmospheric Boundary Layer.

It is difficult to fit these activities into the performance measurement indicators being used within Management Services. They identify more closely with the performance review and evaluation exercise of science and service activities that was conducted on a more rigorous level in 1978 than previously as part of the annual review and planning process. The pressures of inflation and government constraint combined with growing demands for Institute research and survey services continue to increase the administrative workload on the Director General's office. The staff position, Program Analysis and Liaison, has greatly assisted in offsetting this situation.

LIBRARY

S. Thomson - Librarian

C. Firth - Library Clerk

Nineteen seventy-eight was a year of expansion for the Library with the Earth Physics Branch of the Department of Energy, Mines and Resources adding their 20-year accumulation of geophysics materials to the existing Library collection. Our holdings increased by at least 30% and some of the long runs of bound journals proved most welcome to many users. The Geological Survey of Canada (DEMR) enhanced the journal subscription list by 20 titles but have not yet contributed to the monograph collection. There were noticeable increases in borrowings, on-line searches and reference requests -- all welcome. We look forward in 1979 to functioning as a fully integrated library service serving all Institute needs.

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, 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.

- Working Committee for Global Investigations of Pollution in the Marine Environment (GIPME)

HYDROGRAPHIC DIVISION

Ages, A.B.

- Environmental Emergency Working Group, Victoria Zone
- Navigational Relative Risk Index Sub-group
- Technical Committee (DOE), Annacis Island Sewage Treatment

Bolton, M.

Hydrographic Committee CIS

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 - past 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)

Lighthouse - Canadian Hydrographers Association - assistant editor

Survey Technology Advisory Committee - Camosun College

Workshop Group on Offshore Surveys for Mineral Resource Development

Board of Trustees, Maritime Museum of B.C.

International Hydrographic Technical Conference Committee (1979)

Canadian Institute of Surveying, Victoria Branch, Vice-chairman

Canadian Hydrographers Association, Pacific Region - Executive Member

Smithers, F.R.

Public Information Group, DOE Pacific

Regional Committee on Interagency Routing of Navigational Information

Advisory Board, Camosun College

Smith, A.

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

Watt, J.V.

Electronics Technology Program Advisory Committee, Camosun College

Wills, R.

Regional Hydrographic Survey Officers' Appraisal Board - chairman

Regional Committee on Interagency Routing of Navigational Information

Survey Technology Advisory Committee, BCIT

Regional Board, Pacific Region, Estuary Working Group

Wigen, S.O.

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

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

Joint Federal/Provincial Tsunami Working Group - Chairman

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Laboratory Safety Committee, Ocean Chemistry - Chairman

Institute Safety Committee

Institute Cafeteria Committee

Macdonald, R.W.

Ocean Dumping Technical Committee, Pacific Region

Thompson, J.A.J.

Institute Safety Committee

Laboratory Safety Committee, Ocean Chemistry

Pacific Nuclear Activation Research Association - Secretary

Wong, C.S.

Environmental Contaminant Act Advisory Committee, Pacific Region

NRC Associate Committee on Marine Analytical Standards, Atlantic Regional Laboratory

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.

Hon. Prof. - University of Victoria

Research Associate - Royal Ontario Museum

Visiting Professor - College of Marine Sciences, University of Delaware

Regional Ocean Dumping Advisory Committee - OAS Representative

CCREM Shoreline Management Conference - OAS Delegate

Standards Council of Canada - Delegate International Conference

Standards Council of Canada - ISO/TC/147/Sc5 member

Chairman - A.S.L.O. local organization committee, 1978 meetings

Chairman - First International Aquatic Oligochaete Biology Symposium/ International Assn. of Theor. and Applied Limnology

Graduate Student Committees - University of Victoria (3) UNB (1)

Science Subvention Programme Review Committee - Regional OAS Representative

Fellow, Rawson Foundation

Advisor, North Saanich Municipal Council (Environment)

Guest lecturer, University of Toronto (dedication of A.G. Huntsman library)
ASLO Winter 1978 (symposium speaker)

Nominee - President, N. American Benthological Assn. (President)
- Am. Soc. Limnol. Oceanogr. (member at large)

Denman, K.L.

A.S.L.O. Symposium Chairman

A.S.L.O. Organizing Committee member

Can. Meteorological and Oceanographic Society citations committee chairman

Gardner, G.

A.S.L.O. Organizing Committee (Secretary)

Mackas, D.

A.S.L.O. Organizing Committee (Posters)

OCEAN PHYSICS DIVISION

Farmer, D.M.

- Babine Lake Steering Committee
- American Geophysical Union, Estuarine and Coastal Oceanography Committee

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 Adivosry 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
- Canadian National Committee for SCOR

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

Beaufort Sea Contingency Planning Task Force; Scientific Advisor

Beaufort Sea Scientific Response Plan; Coordinator

Arctic Petroleum Operators Association/Federal Govt. Steering Committee for Research on Offshore Problems

Miyake, M.

Canadian GARP Scientific 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.

SCOR WG 47 - FEGG - Oceanography Pacific

Murty, T.S.

Tsunami Committee of International Union of Geodesy and Geophysics - Vice-chairman

Canadian Meteorological and Oceanographic Society - Recording Secretary

Organizing Committee of Symposium on St. Lawrence Estuary held at University of Quebec in April '78

Organizing Committee of Symposium on long waves in the ocean held at Ottawa in June '78

Nasmyth, P.W.

Canadian National Committee for SCOR

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)

Canadian Committee on the Proposed Formation of ICES of the Pacific (International Council for Scientific Investigation of the North Pacific)

Organizing Committee of the 13th Canadian Meteorological and Oceanographic Congress (Canadian Meteorological and Oceanographic Society)

Thomson, R.E.

RSCC Task Force on the proposed Floating Dry Dock, Burrard Inlet

Associate Editor, Atmosphere and Oceans

Treasurer, XIII Congress CMOS

COMPUTING SERVICES

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

INDUSTRIAL LIAISON AND CONTRACT ACTIVITY

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 1978

Numerical modelling study of the movement of Fraser River discharge in the Southern Strait of Georgia, Part II University of B.C., Vancouver, B.C.	2,000
Study of the effects of dumping dredge spils containing wood debris on benthic communities in Port Alberni, B.C. Dobrocky Seatech Ltd., Victoria, B.C.	2,000
Development of software for random access memory system (RAMS) buoy data A.S. Thorndike, Seattle, Washington USA	254

Preparation of check standards, calibration graphs and other procedures for chemical analysis of water samples L. Barry, Victoria, B.C.	11,500
Software development and modification of existing programs of portable hydrographic acquisition systems (PHAS) Multilek Incorporated, Ottawa, Ontario	4,500
Collating and plotting of oceanographic data C. Wallace, Sidney, B.C.	3,290
Development of computer programs for hydraulic research CPRO Computing Enterprises Incorporated, Victoria, B.C.	23,748
Development of computer programs for numerical modelling. Nawitka Renewable Resource Consultants Ltd., Ladysmith, B.C.	4,095
Development of computer programs for remote sensing Apocalypse Enterprises Incorporated, Victoria, B.C.	15,998
Development of computer programs for Ocean Mixing Apocalypse Enterprises Incorporated, Victoria, B.C.	17,581
Development of a microprocessor based, precision Acoustic Navigation System for surveying from a small submersible Mesotech Systems Ltd., North Vancouver, B.C.	227,000
Oceanic water properties sampling and measurement program aboard the weathership CCGS *Quadra* Seakem Oceanography Ltd., Sidney, B.C.	55,000
Provision of support to the Institute of Ocean Sciences to carry out oceanographic programs Bastion City Charters, Nanaimo, B.C.	21,258
Development of computer programs for numerical modelling Dobrocky Seatech Ltd., Victoria, B.C.	19,910
Collection and analysis of data on the spatial distribution of plankton in B.C. coastal waters G.C. Louttit, Sidney, B.C.	10,595
Laboratory study of behaviour of oil and gas particles in salt water relating to deep oil well blowouts University of Calgary, Calgary, Alberta	52,557
Sediment and oligochaete sample collection from the Fraser River P. Chapman, Victoria, B.C.	1,450
Documentation of oceanographic station data E. Wong, Victoria, B.C.	1,460
Oceanographic support to Institute of Ocean Sciences Dobrocky Seatech Ltd., Victoria, B.C.	20,000

Study on the behaviour, pathways residence time and toxicity of polychlorinated biphenyls (PCB) in the marine environment Seakem Oceanography Ltd., Sidney, B.C.	25,000
Analysis of the behaviour, pathways, residence time and toxicity of tetraethyl lead in the marine environment Seakem Oceanography Ltd., Sidney, B.C.	25,000
Hydrocarbon baseline study of Kitimat Harbour, Douglas Channel and approaches Seakem Oceanography Ltd., Sidney, B.C.	281,797
Analysis of B.C. coastal water data from the Department of Fisheries and Environment color spectrometer Seakem Oceanography Ltd., Sidney, B.C.	7,000
Biological oceanographic research support to the Institute of Ocean Sciences University of Victoria, Victoria, B.C.	7,500
Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni Dobrocky Seatech Ltd., Victoria, B.C.	29,010
Collection and supply of hydrographic field data for correction and up-dating navigational charts and sailing directions I.J. Campbell, Sidney, B.C.	16,486
Analysis of oceanographic data collected in Queen Charlotte Sound, Hecate Strait and Johnstone Strait B. Choo, Victoria, B.C.	6,090
Deployment of controlled ecosystem enclosures J & J Divers, Victoria, B.C.	800
Deep water blowout trajectory models for the Lancaster Sound Region Arctic Sciences Ltd., Sidney, B.C.	23,859
Numerical modelling studies of the estuarine circulation in the Strait of Georgia system, Part I University of B.C., Vancouver, B.C.	10,000
Support for the West Coast Ocean Dumping Program Dobrocky Seatech Ltd., Victoria, B.C.	7,214
Examination of boundary conditions for linearized shallow water equations F. Milinazzo, Victoria, B.C.	2,000
Examination of evidence for an internal tide in Alberni Inlet Seakem Oceanography Ltd., Sidney, B.C.	4,402

Provision of oceanographic support for a surface current study in Juan de Fuca Strait Ivanhoe Enterprises, Vancouver, B.C.	7,344
Development of a meaningful criteria for ocean disposal of dredged or sedimentary material, Part II Seakem Oceanography Ltd., Sidney, B.C.	10,241
Development of a meaningful criteria for ocean disposal of dredged or sedimentary material, part I Can Test Ltd., Vancouver, B.C.	10,421
Study on the methylation of arsenic in marine sediments and interstitial waters in Rupert Inlet, B.C. Beak Consultants Ltd., Vancouver, B.C.	11,738
Oceanographic observations aboard CCGS *Quadra* T. Juhasz, Victoria, B.C.	6,512
Development and testing of moorings for use in areas of negligible horizontal magnetic fields, Phase I Dobrocky Seatech Ltd., Victoria, B.C.	21,201
Deployment of moorings in areas of negligible horizontal magnetic fields, Phase II Dobrocky Seatech Ltd., Victoria, B.C.	12,528
Analysis of phytoplankton primary productivity samples from the B.C. Continental Shelf J.R. Forbes, Ladysmith, B.C.	480
Modifications to the software of the multi-probe data acquisition system Apocalypse Enterprises Inc., Victoria, B.C.	5,000
Identification and sorting of B.C. marine zooplankton samples W. Carolsfeld, Victoria, B.C.	4,770
Identification and sorting of B.C. marine zooplankton samples H.A. Sefton, Victoria, B.C.	4,770
Documentation of oceanographic data from the ice drift buoy program S. Hill, Victoria, B.C.	3,000
Processing of physical oceanographic data as returned by oceanographic observers from the weathership *Quadra* and *Vancouver* Interact Computing Services Ltd., Victoria, B.C.	3,381
Feasibility study using ships of opportunity to collect physical and biological oceanographic data Seakem Oceanography Ltd., Sidney, B.C.	130,485

Modifications to the Dept. of Fisheries and Environment submersible *Pisces IV* to permit safe operation in deep ocean areas International Hydrodynamics Ltd., Vancouver, B.C.	262,473
Determination of the lead methylating capacity of Pacific coastal marine sediments Beak Consultants Ltd., Vancouver, B.C.	7,358
Examination of the variability of upwelling on the West Coast of Vancouver Island and its relationship to the flushing of Alberni Inlet Beak Consultants Ltd., Vancouver, B.C.	7,980
Analysis of sediment samples for polychlorinated biphenyls Seakem Oceanography Ltd., Sidney, B.C.	6,300
A physical oceanographic study in the Kitimat Area (Amendment) Dobrocky Seatech Ltd., Victoria, B.C.	152,225
Research on the methylation of arsenic in marine sediments and interstitial waters in Rupert Inlet, B.C. Beak Consultants, Vancouver, B.C.	9,650
Analysis of plankton samples from B.C. coastal waters G. Gardner, Brentwood Bay, B.C.	9,500
Investigation of tubificid oligochaete niches and their role in mobilization of some heavy metals in lake sediments Beak Consultants Ltd., Mississauga, Ontario	32,795
Historical examination of tide graphs for evidence of tsunamis and tabulation of results M. Lane, Victoria, B.C.	1,000
Analysis of samples of marine lolothurian, molpadia intermedia for determination of copper, zinc and cadmium Can Test Ltd., Vancouver, B.C.	1,377
Development of software routine for translating and calibrating sea data tape reader output Interact Computing Services Ltd., Victoria, B.C.	2,050
Provide descriptions of B.C. Marine Oligochaetes H.R. Baker, Victoria, B.C.	2,300
Hydrocarbon determination in seawater Seakem Oceanography Ltd., Sidney, B.C.	28,500
Laboratory study of behaviour of oil and gas particles in salt water relating to deep oil well blowouts University of Calgary, Calgary, Alberta	55,000

SEAKEM $18,780.00

DOBROCKY $264,088.00

PUBLICATIONS

Institute of Ocean Sciences, Patricia Bay, 1978 Annual Report

PACIFIC MARINE SCIENCE REPORTS

PMSR 78-1

Offshore Oceanography Group	Oceanographic observations at Ocean Station P - 29 July - 14 September 1977. Volume 84.

PMSR 78-2

Giovando, L.F.	Observations of seawater temperature and salinity at British Columbia shore stations 1974.

PMSR 78-3

Tabata, S.	An examination of the quality of sea-surface temperatures and salinities observed recently in the northeast Pacific Ocean.

PMSR 78-4

Herlinveaux, R.H., D.B. Fissel & S.E.G. Wilson	Oceanographic observations in Barrow Strait and Wellington Channel, N.W.T. April 1973.

PMSR 78-5

Wigen, Sydney O.	Historical study of tsunamis - an outline.

PMSR 78-6

Foreman, M.G.G.	Manual for tidal currents analysis and prediction.

PMSR 78-7

Offshore Oceanography Group	Oceanographic observations along Line P and off the coast of British Columbia 19 August - 10 September, 1975.

PMSR 78-8

Giovando, L.F.	Observations of seawater temperature and salinity at British Columbia shore stations 1975.

PMSR 78-9

Brinkhurst, R.O. (Ed.)	Report on ocean dumping R and D Pacific Region Fisheries and Environment Canada 1976-1977.

PMSR 78-10

Macdonald, R.W., M.E. McFarland, S.J. De Mora, D.M. Macdonald & W.K. Johnson — Oceanographic data report Amundsen Gulf August-September 1977.

PMSR 78-11

Thompson, J.A.J. & D.W. Paton — Heavy metals in benthic organisms from Point Grey dumpsite - Vancouver, B.C. - A preliminary report.

PMSR 78-12

Giovando, L.F. — Observations of seawater temperature and salinity at British Columbia shore stations 1976.

PMSR 78-13

Mortimer, A., D.H. Gray & R.M. Eaton — A Loran-C calibration, the West Canadian Chain offshore operations and data analysis.

PMSR 78-14

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 9 September - 26 October 1977. Volume 85.

PMSR 78-15

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 17 October - 7 December 1977. Volume 86.

PMSR 78-16

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 2 December 1977 - 11 January 1978. Volume 87.

PMSR 78-17

Mortimer, A., D.H. Gray & R.M. Eaton — A Loran-C calibration, the West Canadian Chain inshore operation and data analysis.

PMSR 78-18

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 6 January - 15 February 1978. Volume 88.

PMSR 78-19

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 10 February - 29 March 1978. Volume 89.

PMSR 78-20

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P - 24 March - 10 May 1978. Volume 90.

PMSR 78-21

Hill, S.H., D.B. Fissel & H. Serson	A study of wind and atmospheric pressure in Eastern Parry Channel, N.W.T. - Summer, 1977.

PMSR 78-22

Mortimer, A., R.M. Eaton & D. Gray	A Loran-C calibration, West Canadian Chain synchronized time of arrival measurements.

PMSR 78-23

Greisman, Paul and Robert A. Lake	Current observations in the channels of the Canadian Arctic Archipelago adjacent to Bathurst Island.

PMSR 78-24

Macdonald, R.W., D.M. Macdonald and P.S. Munro	Oceanographic data report Kitimat Arm, Porpoise Harbour February 1977.

PMSR 78-25

Watt, John V.	Extending the bathymetric capability of the M.V. Pandora II.

PMSR 78-26

Hill, S.H.	A guide to the effects of underwater shock waves on arctic marine mammals and fish.

PMSR 78-27

Seakem Oceanography Ltd.	Oceanographic observations at Ocean Station P - 5 May - 21 June 1978. Volume 91.

PMSR 78-28

Gower, J.F.R., ed.	Passive radiometry of the ocean.

CONTRACTOR REPORT SERIES

CRS 78-1

Fissel, D.B., Arctic Sciences, Ltd.	Measurements of the direction sensitivity of three current meters as a function of magnetic field intensity.

CRS 78-2

MacNeill, M.R., B.R. de Lange Boom and D. Ramsden, Seakem Oceanography, Ltd.	Radar tracking of ice in the Griffith Island area of Barrow Strait, N.W.T.

CRS 78-3

Fissel, D.B. and G.R. Wilton, Arctic Sciences Ltd.	Subsurface current measurements in Eastern Lancaster Sound, N.W.T. - Summer 1977.

CRS 78-4

Fissel, D.B. & J.R. Marko, Arctic Sciences Ltd.	A surface current study of Eastern Parry Channel, N.W.T., Summer 1977.

CRS 78-5

Marko, J.R., Arctic Sciences Ltd.	A satellite imagery study of Eastern Parry Sound.

OTHER PUBLICATIONS - 1978

Aubin, F., T.S. Murty and M.I. Eb-Sabh. 1978. Numerical simulation of the movement and dispersion of oil slicks in the upper St. Lawrence estuary, preliminary results. Le Naturalist Canadien. (in press)

Brinkhurst, R.O. 1978. Freshwater Oligochaeta in Canada. Can. J. Zool. 56: 2166-2175.

Corneil, D.G. & M.E. Woodward, 1978. A comparison and evaluation of graph theoretical clustering Techniques. INFOR, Vol. 16, No. 1, pp. 74-89.

Crean, P.B. 1978. A numerical model of barotropic mixed tides between Vancouver Island and the mainland and its relation to studies of the estuarine circulation. Hydrodynamics of Estuaries and Fjords. Proceedings of 9th Colloquium of Ocean Hydrodynamics. Amsterdam,Elsevier pp. 283-314.

Cretney, W.J., C.S. Wong, D.R. Green and C.A. Bawden, 1978. Long-term fate of a heavy fuel oil in a spill-contaminated B.C. coastal bay. J. Fish. Res. Bd. Can., 35(5), 521-527.

Denman, K.L. and A.W. Herman, 1978. Space-time structure of a continental shelf ecosystem measured by a towed porpoising vehicle. J. Mar. Res. 36: 693-714.

Denman, K.L. and D.L. Mackas, 1978. Collection and analysis of underway data and related physical measurements. In: Spatial Pattern in Plankton Communities. Editor, John H. Steele, Plenum Publishing, New York.

Eaton, R.M., A.R. Mortimer and D.H. Gray. Accurate Chart Latticing for Loran C. Lighthouse, Sp. Ed., April 1978. pp. 11-17.

Farmer, D.M. & J.D. Smith, 1978. Nonlinear internal waves in a fjord. In: Hydrodynamics of Estuaries and Fjords: Proceedings of the 9th Liege Colloquium on Ocean Hydrodynamics. Amsterdam, Elsevier pp. 465-495.

Farmer, D.M., 1978. Observations of long nonlinear internal waves in a lake. J. Phys. Oceanog. 8: 63-73.

Freeland, H.J., 1978. (Coauthor in the Mode Group) The Mid-Ocean Dynamics Experiment. Deep Sea Research 25(10), 859-910.

Gargett, A.E., 1978. Microstructure and fine structure in an upper ocean frontal regime. J. of Geophysical Res. 82(C10), 5123-5134.

Gower, J.F.R. & B. M. Oliver, 1978. Observations of coastal water surface currents using an airborne inertial sighting system. J. Geophys. Res. 83, 1941-1946.

Irwin, B., W.G. Harrison, K.L. Denman & T. Platt, 1978. Phytoplankton productivity and nutrient measurements at the edge of the continental shelf off Nova Scotia, between April 29 and May 11, 1977. Fish.Mar. Service Data Rept. No.62, 90p.

Kremling, K., J. Piuze, K. von Bruckel, & C.S. Wong, 1978. Studies on the pathways and effects of cadium in controlled ecosystem enclosures. Marine Biology, 48, 1-10.

Levesque, L., M.I. El-Sabh & T.S. Murty. 1978. Movement des l'eaux indiut par la Maree et le vent dans l'estuaire du St. Laurent. Le Naturalist Canadien. (In press).

Levesque, L., T.S. Murty & M.I. El-Sabh. 1978. Numerical modelling of tidal propagation in the St. Lawrence estuary. International Hydrographic Bulletin. (In press).

Lewis, E.L. and R.G. Perkin. 1978. Salinity: Its definition and Calculation. J. Geophys. Res. Vol. 83, pp. 466-478.

Lewis, E.L. and R.B. Sudar. 1978. A salinity chain for estuarine use. Oceans '78. Inst. Electrical & Electronic Engineers Inc., New York. Publ. #78, CH, 0134-7, OEC.

Luternauer, J.L., R.H. Linden and R.E. Thomson. 1978. Applications of side-scan sonar to Geoenvironmental Research in the coastal waters of British Columbia, Scientific and Technical Notes in Current Research, Part B, Geol. Surv. Can. pp.181-186.

Melling, H. & R. List. 1978. Acoustic Doppler sounding of falling snow. J. Appl. Meteor. 17: 1267-1273.

Melling, H. & R. List. 1978. Doppler velocity extraction from atmospheric acoustic echoes using a zero-crossing technique, J. Appl. Meteor. 17: 1274-1285.

Milne, A.R. and B.D. Smiley. 1978. Offshore Drilling in Lancaster Sound. Possible Environmental Hazards. Sidney, Institute of Ocean Sciences, Patricia Bay. 98 pp.

Milne, A.R. 1978. Oil, Ice and Climate Change. The Beaufort Sea and the search for oil. Beaufort Sea Overview Report. Sidney, Beaufort Sea Project. 103 pp.

Mortimer, A.R., R.M. Eaton and D.H. Gray. 1978. Calibration of the West Canadian Loran C Chain. Canadian Aeronautics and Space Journal. Vol. 24, No.3, pp. 129-135.

Murty, T.S. & R.J. Polavarapu. 1978. Influence of an ice layer on the propagation of long waves. Marine Geodesy. (In press).

Murty, T.S. 1978. Moving boundary problems - discontinuous flows - catastrophe theory and numerical modelling. In: Computing methods in Geophysical Mechanics. New York, American Society of Civil Engineers. pp. 79-92.

Murty, T.S. 1978. Submarine land-slide generated water waves in Kitimat Inlet, B.C. Proc. of the 25th Annual Meeting of the Pacific Northwest Region of the American Geophysical Union. (In press).

Murty, T.S. 1978. Tsunami generation by meteorite impacts. Proceedings of the Long Wave Symposium. Edited by G. Godin, Ocean and Aquatic Sciences, Fisheries and Environment Canada, Ottawa. (In press).

Nasmyth, P.W. 1978. Instruments and Methods in Air-Sea Interaction, Techniques of Measurement from Towed Vehicles and Submersibles, Presented at NATO Advanced Study Institute on Instruments and Methods in Air-Sea Interaction, Norway, April. 30 pp. (In press)

Perkin, R.G. and E.L. Lewis. 1978. Mixing in an arctic fjord. J. Phys. Oceanography, Vol. 8, pp. 873-880.

Riser, S.C., H.J. Freeland and H.T. Rossby, 1978. Mesoscale motions near the deep western boundary of the North Atlantic. Deep Sea Research 25(12).

Sandilands, R.W. 1978. Captain James Cook. R.N., Hydrographer. The Canadian Surveyor, (in press).

Stewart, R.W., 1977. Oil and the Ocean, Proceedings of the World Conference Towards a Plan of Actions for Mankind. Vol. 2 pp. 119-122.

Stewart, R.W., 1978. The Oceans, the Climate and People (with a view from Mars). Atmosphere-Ocean 16(4), 367-376.

Stewart, R.W., 1978. Ocean Variability - The Influence of Atmosphere Processes. Advances in Oceanography, 213-219 pp.

Stewart, R.W., 1978. The Role of Sea Ice in Climate. Oceanus. 21(4): 47-57.

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Tabata, S. 1978. Comparison of observations of sea surface temperatures at Ocean Station P and NOAA buoy stations and those made by merchant ships travelling in their vicinities, in the northeast Pacific Ocean. J. Applied Meteorology, 17(3): 374-385.

Tabata, S. 1978. An evaluation of the quality of sea surface temperatures and salinities measured at Station P and Line P in the northeast Pacific Ocean. J. Phys. Oceanogr. 8(6): 970-986.

Tabata, S. 1978. On the accuracy of sea-surface temperatures and salinities observed in the northeast Pacific Ocean. Atmosphere-Ocean 16(3): 237-247.

Thomson, R.E. and J.L. Luternauer, 1978. The tidal regime and sedimentation patterns in Johnstone Strait British Columbia, Scient. and Tech. notes in Current Res., Part A, Geol. Surv. Can.

Wigen, S.O. 1978. Canada's Role in the International Tsunami Warning System. Proceedings of the 17th Annual Canadian Hydrographic Conference. Lighthouse, Special Edition, pp. 18-24.

Wigen, S.O. 1978. Some Developments and Applications in Tsunami Research. Proceedings of International Symposium on Long Waves in the Ocean. Ottawa, Marine Sciences Directorate, Manuscript Report Series. (In press).

Wong, C.S. 1978. Carbon dioxide -- a global environmental problem into the future. Marine Pollution Bulletin, Vol. 9, No. 10.

Woodward, M., 1978. Measurement of currents in narrow passes using in situ pressure gauges. Proceedings of the 17th Annual Canadian Hydrographic Conference. Lighthouse, Special Edition, pp. 43-50.

Yorath, C.J., B.D. Bornhold and R.E. Thomson. 1979. Oscillation megaripples on the northeast Pacific Continental Shelf, J. Marine Geology, (in press).

PERMANENT STAFF 1978

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

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

Aanhout, D.L. van
*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.
Hall, E.J.
Harbar, M.S.
Jones, K.M.G.
*Kwiatkowski, B.S.
Lapp, B.I.; B.A. (Victoria)
Lohrmann, B.A.; B.Sc., M.Sc. (Guelph)
Mathias, B.
McKenzie, S.D.
Miles, M.L.
Parsons, J.E.
Peirson, E.
*Powers, M.A.
*Raine, G.M.
Reinstein, H.G.
Sabourin, J.T.
Smith, R.M.
Thomas, C.D.
Thomson, L.S.C.; B.A. (Saskatchewan) B.L.S. (Brit.Col.)
van Dusen, T.S.

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

*Left during 1978

HYDROGRAPHIC DIVISION

Bolton, M. - Regional Hydrographer

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

*Left during 1978

Watt, B.M.
Watt, J.W.; B.A.Sc.(EE) (Brit.Col.), P.Eng.
Whincup, G.
Wigen, S.O.; B.A.Sc. (Brit.Col.), P.Eng.
Wills, R.; Master, F.G.
Wood, D.J.; Dip. BCIT
Woods, M.V.; Dip. BCIT
Woodward, M.J.; B.Sc. (Victoria, M.Sc. (Toronto)

OCEAN PHYSICS DIVISION

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

Bell, W.H.; B.A.Sc. (Brit.Col.), M.Sc. (Hawaii), P.Eng.
Bigham, R.H.
Chase, G.W.; Dip. BCIT
Cooke, R.A.
Crean, P.B.; B.Sc. (Dublin), M.A.Sc. (Toronto), Ph.D. (Liverpool)
de Jong, C.
Farmer, D.M.; B.Com., M.Sc. (McGill), Ph.D. (Brit.Col.)
Freeland, H.J.; B.A. (Essex), Ph.D. (Dalhousie)
Gargett, A.E.; B.Sc. (Manitoba), Ph.D. (Brit.Col.)
Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D. (Cantab)
Henry, R.F.; B.Sc. (Edinburgh), Ph.D. (Cantab)
Herlinveaux, R.H.
Kamitakahara, G.R.; B.Sc. (Toronto)
Koppel, A.W.
Kimber, P.M.
Kuwahara, L.S.C.; B.Sc. (Brit.Col.)
Lake, R.A.; B.Sc. (Brit.Col.), M.Sc. (Washington)
Lewis, E.L.; B.Sc., M.Sc., Ph.D. (London)
Linguanti, J.
Love, J.
McNeill, J.M.
Meikle, J.H.
Milne, A.R.; B.A.Sc. (Toronto), M.Sc. (McGill)
Minkley, B.G.; Dip. BCIT
Miyake, M.; B.S.(EE) (Drexel), M.S., Ph.D. (Washington)
Moorhouse, S.W.
Murty, T.S.; B.Sc. (Andhra), M.Sc. (Andhra), M.S. (Chicago), Ph.D. (Chicago)
Perkin, R.G.; B.A.Sc., M.Sc. (Brit.Col.)
Richards, D.L.
Sieberg, D.G.; Dip. VVI
Smiley, B.D.; B.Sc., M.Sc. (Alberta)
Spearing, L.A.F.; B.Sc. (Brit.Col.)
Stickland, J.A.
Stucchi, D.J.; B.A.Sc. (York), M.Sc. (Dalhousie)
Sudar, R.B.; B.A.Sc. (Toronto)
Tabata, S.; B.A., M.A. (Brit.Col.), D.Sc. (Tokyo)
Teichrob, R.C.; Dip. BCIT
Thomson, R.E.; B.Sc., Ph.D. (Brit.Col.)
*Walker, E.R.; B.Sc. (Manitoba), M.A. (Toronto), Ph.D. (McGill)
Wallace, J.S.

OCEAN ECOLOGY LABORATORY

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

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

*Left during 1978

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.)
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.)
Soutar, T.J.; Dip. BCIT
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)
Norton, N.St.C.	Master F.G.; Assistant Marine Superintendent (Deck)
Parkinson, R.W.	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
Redman, D.J.	

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
Olcen, P.	Engineer 1st Class Motor
*Orr-Hood, J.	Engineer 4th Class Motor; 2nd Engineer

CSS *WM. J. STEWART*

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

* Left in 1978

CSS *VECTOR*

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

CSS *RICHARDSON*

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

MV RADIUM EXPRESS

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

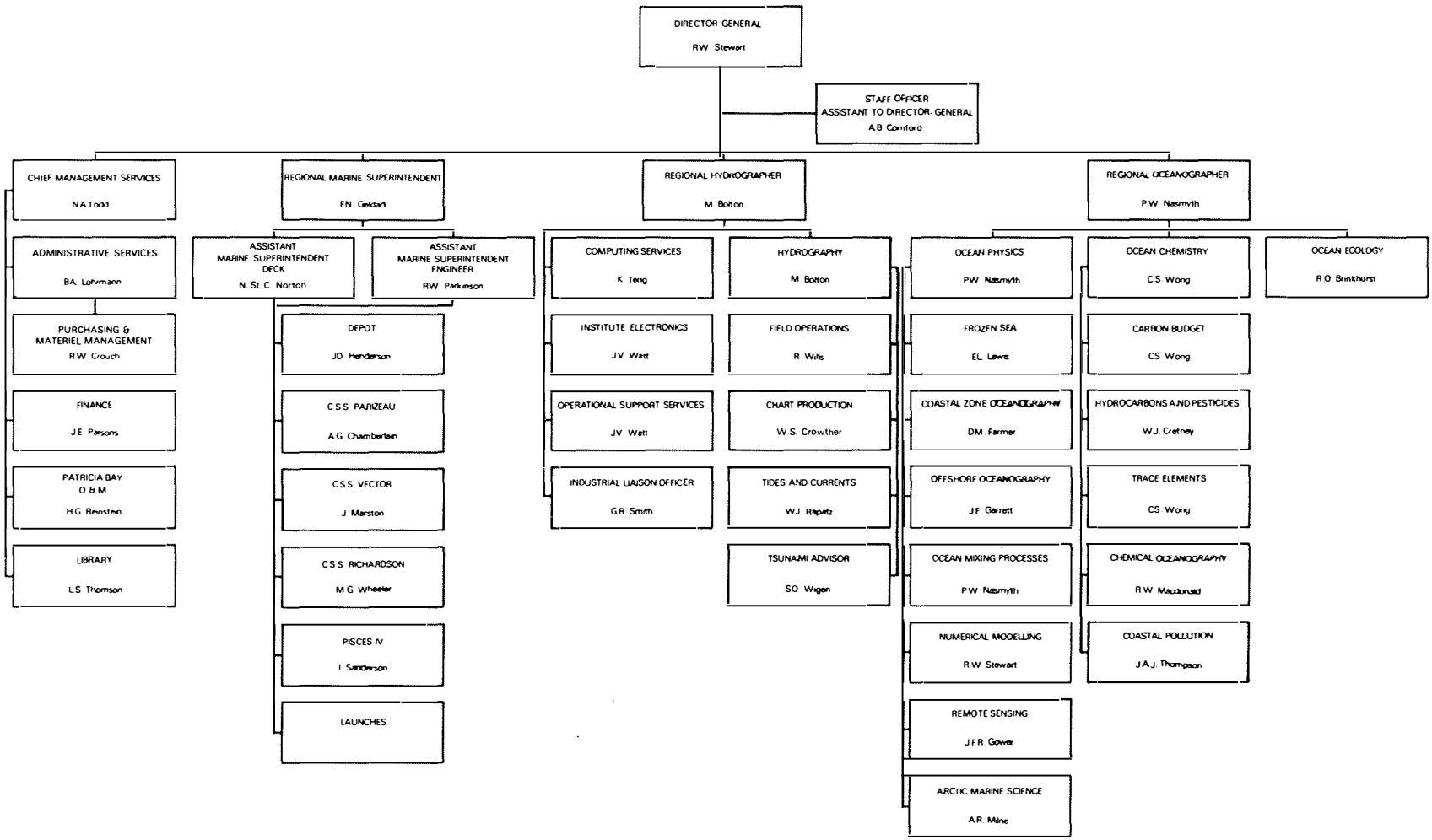
MV PANDORA II (Charter)

Jones, R.	Master
*Tuck, C.	Chief Engineer
Newton, J.	Chief Engineer

PISCES IV

Sanderson, I.	Chief Pilot
Chambers, F.	Pilot
Taylor, R.H.	Pilot
Jacobson, R.	Pilot
*Gaudreault, J.	Pilot
Grant, D.	Pilot
Manion, G.W.	Pilot

* Left during 1978



December 1978