PACIFIC MARINE SCIENCE REPORT 72 - 5

MARINE SCIENCES BRANCH
PACIFIC REGION

ANNUAL REPORT 1971

Department of the Environment
Marine Sciences Branch
Pacific Region
512 Federal Bldg
Victoria, B.C.

MARINE SCIENCES BRANCH

PACIFIC REGION

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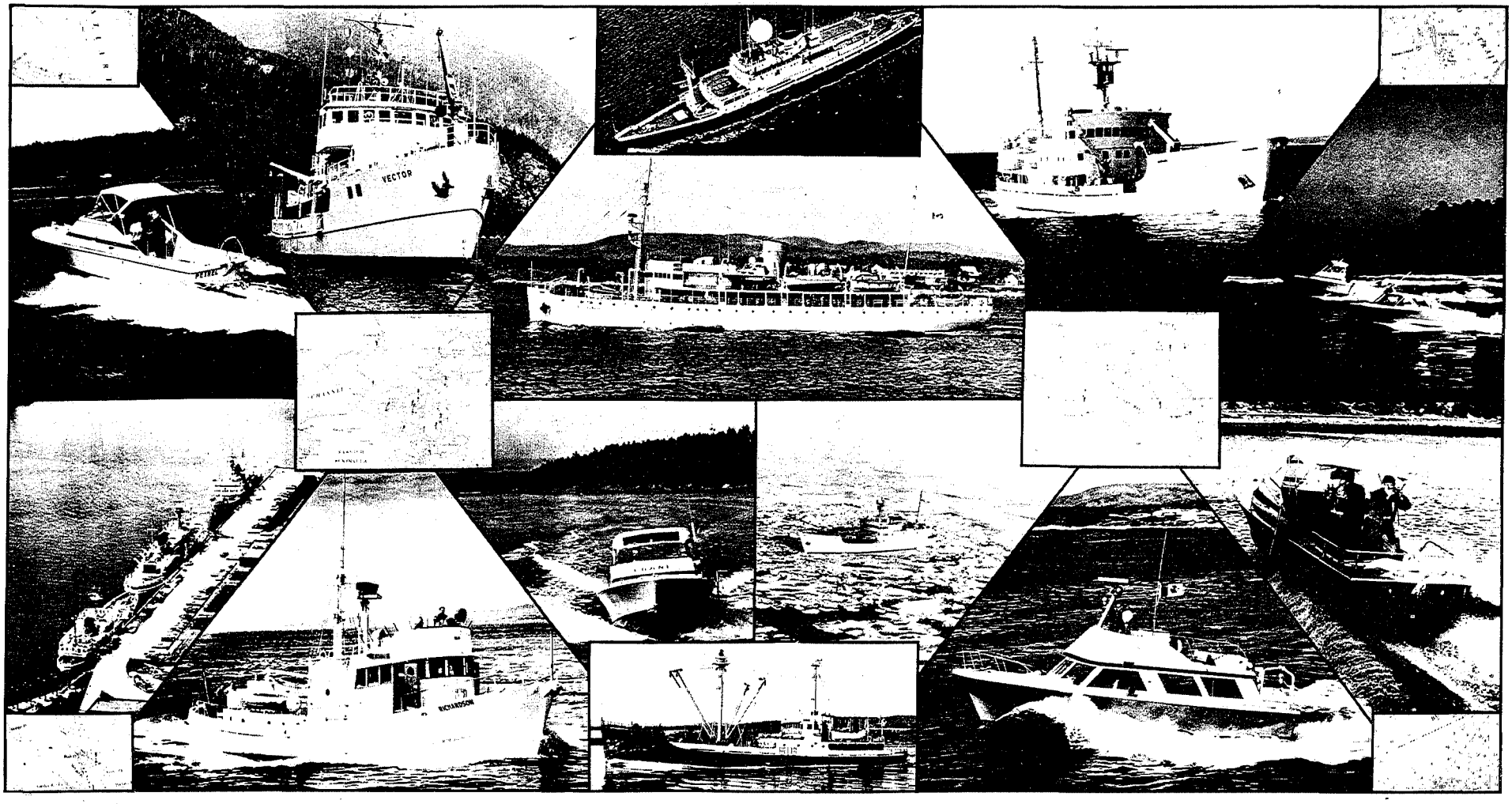
Dodd Narrows
B.C.

Victoria, March 1972.



Ships and launches of the Pacific Region.

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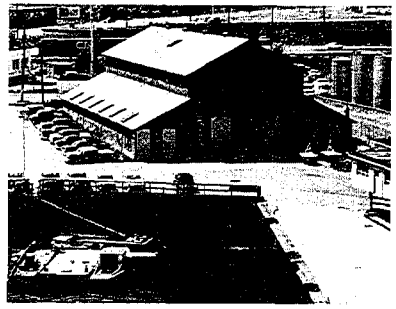
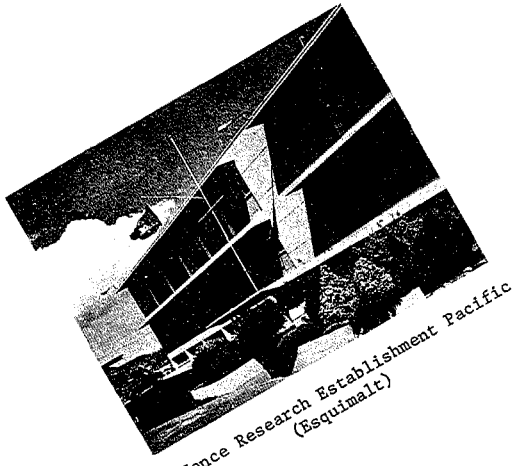
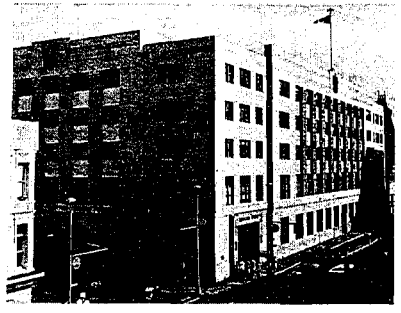


Canadian Hydrographic Service Depot
(Victoria)



Defence Research Establishment Pacific
(Esquimalt)

Pacific Biological Station
(Nanaimo)



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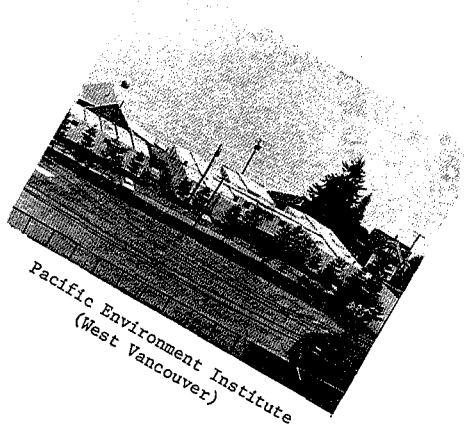
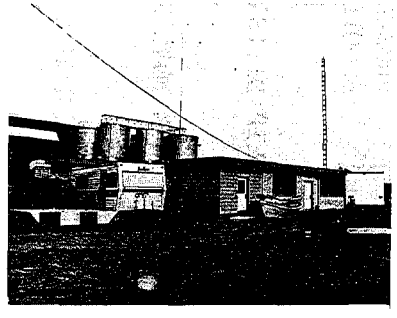
(Victoria)



Pacific Environment Institute
(West Vancouver)



Electronics Laboratory and Oceanography Trailer
(Victoria)

Frozen Sea Research Group
(Esquimalt)

INTRODUCTION

This report for 1971 is the first annual report issued directly by the Marine Sciences Branch, Pacific Region, of Environment Canada. The initiation of an annual report series is in keeping with the significant expansion and extension of Branch activities in the Region.

Expansion of the scope of Marine Sciences activities in the Pacific Region was placed firmly in the plans of the Department of Energy, Mines and Resources from 1962, soon after the Department took on the major federal responsibility for the development of oceanography in Canada. Construction of a West Coast Oceanographic Institute was originally scheduled for the mid 1960's, but was deferred in favour of the Canada Centre for Inland Waters at Burlington. Now the long-awaited build-up on the Pacific is taking place within the framework of the new Department of the Environment.

This build-up occurs at a time when the demands upon hydrography and upon oceanography are changing and expanding rapidly. Nowhere are these new demands felt more intensely than in the Arctic and Pacific areas which are the responsibility of MSB,Pacific. The prospect of greatly increased activity in the Western Arctic and upon the Mackenzie River--and some of this increase has already taken place--requires intensification of charting activities in both areas. Canada has an announced position that the borders of national jurisdiction should be defined as the edge of the continental mass. There is a responsibility, partly hydrographic and partly geophysical, to identify the location of this boundary off Canadian shores, not least in the Pacific and in the Western Arctic.

The quantity of shipping on the west coast is increasing rapidly, new ports are being constructed and the size of vessels making use of these ports is increasing dramatically. All of this puts new demands upon hydrography. The increase in the amount of pleasure traffic--and the still larger increase which must be anticipated--demands new charts of special format covering waters of little interest to commercial shipping.

The increasing public concern with the danger of oil spills and other pollution problems requires greatly improved knowledge of the nature of current systems near our shore, currents which are both tidal and non-tidal. In oceanography the new concern for the health of the oceans with respect to pollution requires a breadth and sophistication of chemical oceanographic effort far beyond what was previously considered adequate.

New thrusts in meteorology, leading to extended range weather forecasts, seasonal forecasts and the need to understand the nature of climate so that man's impact on climate can be ascertained, all put great demands upon oceanography. It has become apparent that the behaviour of the atmosphere, for periods longer than a few days, is to very considerable extent determined by the ocean. Since at Canadian latitudes the air flows are generally towards the east, the Canadian need for information about the variability of oceanographic conditions in the eastern Pacific is great and is increasing.

The survey and research activities of the Region, which form the bulk of this report, were carried out against a backdrop of extensive organizational change. It is a great credit to the staff and to the responsible managers that so much was accomplished.

Some established links have been sundered and many new ones have been forged. The Branch is now part of the Water Management Service of the new Department of the Environment. We find ourselves in the same department as, among others, the Fisheries Service including the Fisheries Research Board, and the Atmospheric Environment Service. These changes have the advantage of bringing us into formal association with many of the groups with which we have had in the past, and will probably have even more in the future, close working associations. On the other hand our former close organizational link with those doing marine geology and geophysics has been broken, since these groups remain within the Department of Energy, Mines & Resources.

Many of the responsibilities of the new department call for co-operative action by two or more of the units within the Department. Recognizing this fact, the Directors of the various departmental units in the Region formed themselves into a Regional Directors' Committee which meets several times a year. Here action concerning such problems as determining the probable consequences of a dam on the Fraser River at Moran, and ascertaining the impact of industrial and residential development of estuaries, is initiated and coordinated. MSB,Pacific has played an active role in the development and functioning of this committee. Another facet of the intensification of inter-service activity has been our participation on numerous task forces, working groups, etc. as listed elsewhere in this report.

Within MSB, Pacific there have also been organizational changes. The operations of the Hydrographic Service continue to form the largest portion of the effort of the Branch in the Region, but the incorporation of other groups and the addition of new staff to these groups has substantially broadened our capabilities and responsibilities.

The Director, R.W. Stewart, and Deputy Director, W.N. English, who were appointed late in 1970, moved to Victoria and took up full-time activities early in the year. P.W. Nasmyth was designated Head of a new Ocean Physics Division. The remaining staff of the Fisheries Research Board Pacific Oceanographic Group at Nanaimo were transferred to the Marine Sciences Branch and joined the Branch's Oceanographic Section at the Pacific Environment Institute in West Vancouver.

The Hydrographic field staff was bolstered by the return of Mr. R.W. Sandilands from a one year appointment as Assistant Regional Hydrographer in Central Region. Mr. John Larkin was a welcome addition as

a secondment for two years from the Headquarters Training Staff. One staff member received a field assignment to Central Region while two of Central Region staff spent the summer in the Western Arctic aboard C.S.S. PARIZEAU. Such staff exchanges not only complement the natural flexibility of the Canadian Hydrographic Service but also ensure a greater inter-regional understanding.

The Hydrographic capabilities of the Region continue to strain to meet navigational requirements in Pacific Coastal Waters, the Beaufort Sea and on the Mackenzie River. Substantial progress was achieved in each of these areas. In addition the Service, in particular its Tidal Section, has provided support for oceanographic activities not only of the Branch but of other elements of the Department and of the University of British Columbia. The traditional statistics for the Hydrography Division for 1971 are as follows:

Stations built	293
Kilometers of sounding	30,602 km
Shoals examined	1,236
Area sounded	17,702 km^2
Number of bottom samples	1,143

The Ship Division has maintained its responsibility of providing ship services for the Branch and for other users of ship time supplied by the Pacific Coast Ship Pool. Ships' crews continue to constitute approximately half of the personnel in the Region.

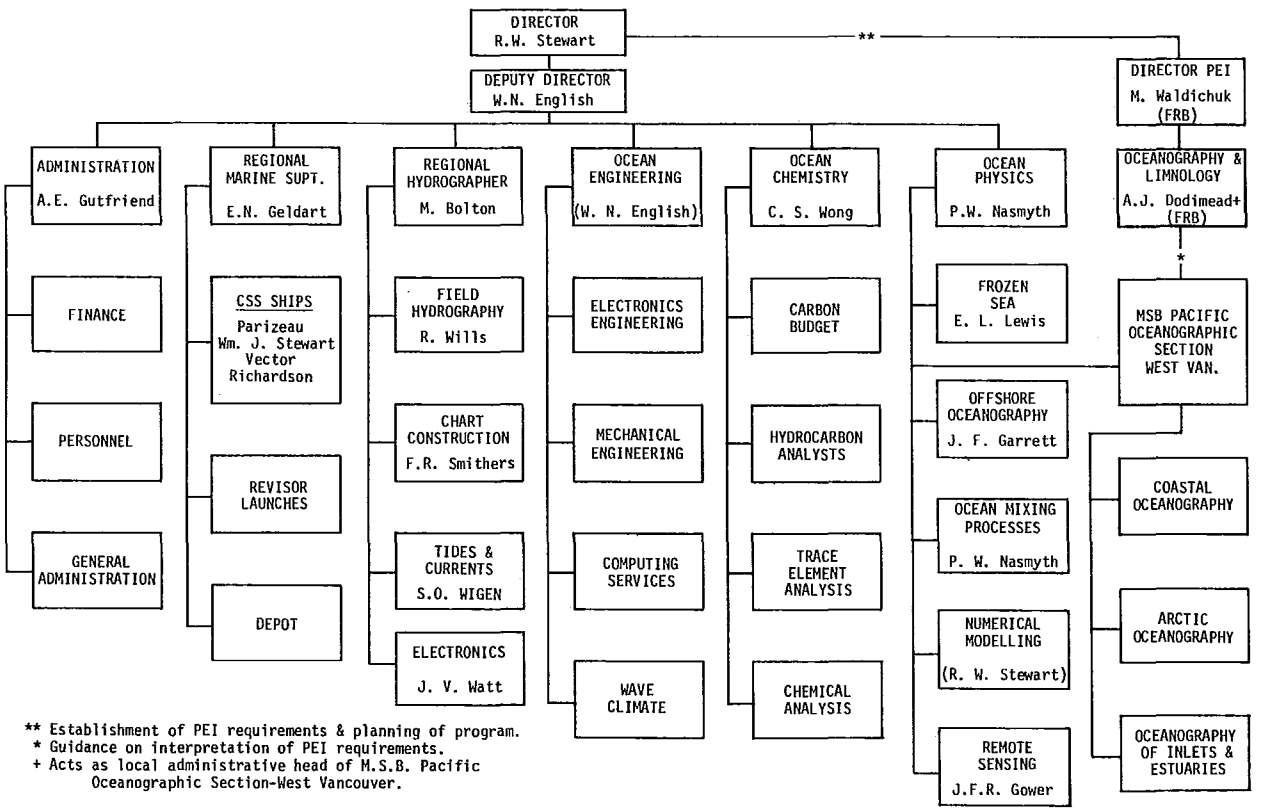
The Ocean Physics Division is spread, too thinly, over several different locations, only the Offshore Oceanography Section being accommodated in the Victoria headquarters. The Frozen Sea Research Group has its own rented accommodation in Esquimalt and also works in the Defence Research Establishment Pacific premises in the Canadian Forces Dockyard. Most of the activity of the Ocean Mixing Section is also carried out within DREP, and is conducted in close collaboration with personnel of that establishment. A substantial element of the division is located in the Pacific Environment Institute in West Vancouver, with the main responsibility of providing physical oceanographic support to P.E.I.'s pollution studies. The wide dispersal of the division continues to hamper appreciably the efficiency of its operation.

The increase in the responsibilities of the Ocean Chemistry Division, which arises in great part from the recognition of the importance of pollution studies, has lead to an authorization for this division to expand substantially. This expansion has had the usual effect, in 1971, of reducing the time available for the division to perform its functions; however, its future capability will be greatly enhanced. The division is housed at the Fisheries Research Board Pacific Biological Station in Nanaimo. The physical separation from other activities of the Branch reduces the effectiveness of inter-actions between oceanographers of different disciplines, so active measures have been taken to rehouse this group in Victoria during 1972.

Despite these difficulties a substantial number of programs showing considerable imagination and initiative are being undertaken. Except for the established time series of Station Papa and on Line P, rather little of the Branch's oceanographic effort is devoted to what might be called "traditional" oceanography. Both the demands upon and the opportunities available to oceanographers are changing rapidly and we expect this situation to continue. In hydrography, too, new techniques are being actively examined and experimented with. We expect the future to be one of rapid evolution and innovation.

While giving full weight to the importance of understanding, managing and protecting the marine environment, we have not forgotten the economic aspects of marine sciences and have done our best, under somewhat difficult circumstances, to encourage the development of Canadian marine technology. Many discussions were held during the year with West Coast companies. One licensing agreement was signed, resulting in $67,000 worth of production by a British Columbia firm, and negotiations on another instrument manufacturing project are underway.

A list of contracts is given later in the report. We have tried to contract out as much of our work as possible. The long time from initiation to contract (3 to 8 months) and the total uncertainty as to when a contract will be let, have caused embarrassment,frustration and severe delays compared to doing the work in house. We intend to persevere, but it is clear that the procedures for letting contracts must be made faster and more predictable, if the Government policy of increasing the ratio of contracts to in-house work is to be effectively implemented.



** Establishment of PEI requirements & planning of program.
* Guidance on interpretation of PEI requirements.
+ Acts as local administrative head of M.S.B. Pacific Oceanographic Section-West Vancouver.

ORGANIZATION CHART

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

Pacific Region has the responsibility for the charting of all navigable waters of Western Canada and the Western Canadian Arctic, including the Athabasca-Mackenzie Waterway. The eastern limit of the region is the Alberta-Saskatchewan border. The responsibility includes not only standard field hydrography but also the measurement and processing of tidal and tidal current information. An active development group is responsible for the evaluation of new equipment and the development of techniques and systems. A small but viable electronics section ensures that all electronic equipment is functional, in addition to providing expertise to the other hydrographic elements.

The Chart Construction and Distribution Section compiles all West Coast field data and maintains the current catalogue of West Coast Charts. It is also responsible for the hand correction of all catalogued charts and the distribution of these charts to chart dealers in Western Canada and the Western United States. During the past year increased support, in the form of graphic analysis and photography, has been given to the Oceanographic Divisions.

The Sailing Directions Section was reactivated with the appointment of Mr. T. Jones from Headquarters as Sailing Directions Officer in December 1970. Since that time B.C. Pilot, Volume 1, has been rewritten in a new, simplified format and considerable progress has been made on a new small boat pilot, covering the cruising waters of the Strait of Georgia.

Our liaison with the Canadian Power Squadrons has been intensified through the introduction of the MAREP (Marine Reporting) program. Both the Chart Construction Section and Field Hydrography played major roles in ensuring that understanding and adequate feedback were established and maintained.

One innovation occurring last year was the direct involvment of the Region in the Hydrography I training program. For the first time the field phase of this basic training program for embryonic field hydrographers took place on the B.C. Coast. CSS WM. J. STEWART was the training ship, and from February through April training activities were conducted in Saanich Inlet. Although the environment did not quite compare to the Carribean setting of previous years,it permitted an adequate program and was perhaps more typical of the normal habitat of Canadian hydrographers.

During the year the Hydrographic Division participated in and was represented at the International Union of Geodesy and Geophysics in Moscow, the Institute of Navigation national meeting in Pasadena, the Canadian Institute of Surveying in Ottawa, the Canadian Hydrographers Conference in Halifax, the National Canadian Power Squadrons convention and the Pacific Northwest Oceanographers Conference, in Victoria.

FIELD HYDROGRAPHY

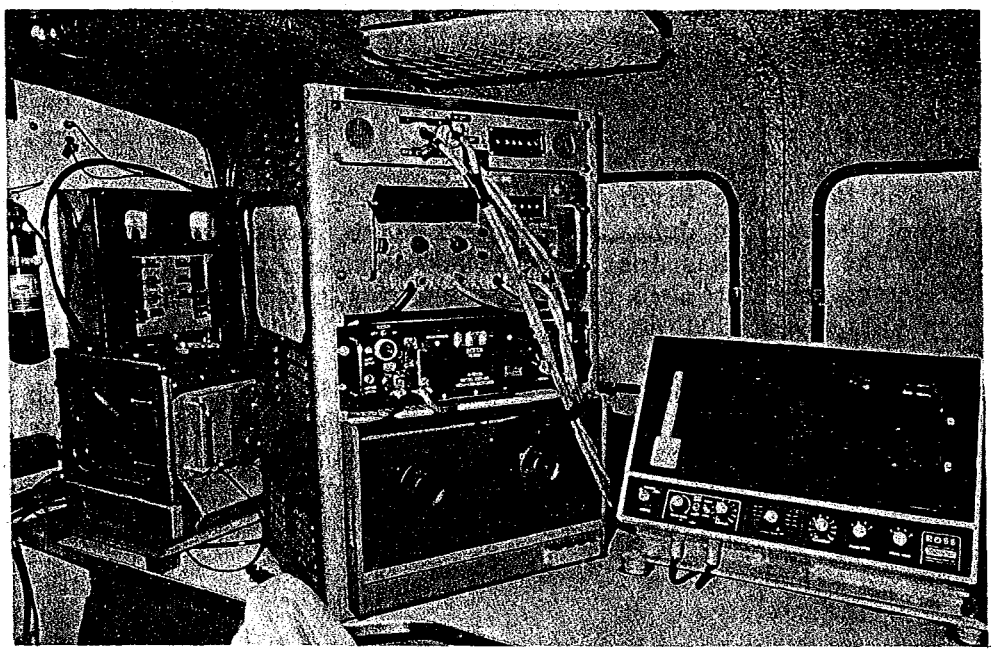
R. Wills, Regional Field Superintendent
E.B. Clarke
F.A. Coldham
G.H. Eaton
J.E.V. Goodwill
K. Highton
R.C. Hlina
W.S. Huggett
L.P. Landry
P.O. Lee
B.M. Lusk
C.G. McIntosh
A.D. O'Connor
R.A. Pierce
R.D. Popejoy
A.R. Raymond
G.E. Richardson
G.W. Rogers
R.W. Sandilands
J.A. Vosburgh
M.V. Woods
P.Y. Yee

This year hydrography from the two major vessels, WM.J. STEWART and PARIZEAU, was a continuation of the surveys commenced in 1970. The REVISOR, besides her revisory work along the south coast, carried out a survey off the southeast corner of Vancouver Island, and the RICHARDSON was retired from the Arctic and brought down to Victoria. A charter vessel, the PILOT II, carried out surveys on the Mackenzie River.

The WM.J. STEWART (under C.G. McIntosh) was employed to carry out surveys in the Strait of Georgia, Malaspina Strait, northern Chatham Sound and Dixon Entrance. These surveys were to up-date the information on the charts and bring them up to modern surveying standards. Some of the information on the charts dated back to the early British Admiralty surveys of 1910. All surveys used RPS and Hydrodist for position, and the Strait of Georgia survey used Mini-Fix in addition to the other methods. A special survey was carried out of Quatsino Narrows. This was a large scale survey of the narrows requested by Utah Construction and Mining Co. to aid in the passage of large ore carriers to their mine in Rupert Inlet. A current survey was carried out at the same time, as tidal currents in the passage exceed six knots.

The PARIZEAU (under W.S. Huggett) worked mainly in the Beaufort Sea, sounding on the continental shelf north of Tuktoyaktuk Peninsula. This was a continuation to the east of last year's survey. This area is of prime importance to the oil companies in their quest for Arctic oil, and is also known for its underwater "pingo" like structures. Positioning was by Decca Lambda, which is maintained by Computing Devices of Canada on a charter from the Polar Continental Shelf project of the Department of Energy, Mines and Resources. GEBCO soundings were taken on the way to and from the Arctic. At the request of the Northern Transportation Company Ltd. a reconnaissance survey was completed of the entrance to Eskimo Lakes.

This year two automated acquisition systems were carried, one of them, ROLAB (Ross Laboratories) was installed aboard the PARIZEAU and the other, known as HAAPS (Hydrographic Acquisition and Processing System) was installed on one of the launches. These automated acquisition systems will now be a permanent part of the hydrographer's tools. The data is processed onboard using a PDP8/E computer and Calcomp-563 plotter.



Launch portion of the Hydrographic Acquisition and Processing System (HAAPS) used to acquire bathymetric data and position fixes, in digital format, on magnetic tape.

For 1972 the Decca Lambda chain will be moved farther east with the master station at Atkinson Point and the slave stations on Baillie Island and Hooper Island. This will allow the survey of the continental shelf in the Beaufort Sea to be completed. The surveys on the continental shelf are multi-disciplined. Magnetic and geological data is also collected in conjunction with the hydrographic data.

Prior to leaving for the Arctic a shore party was established at Fanny Bay and a survey of the area between Vancouver Island and Denman and Hornby Islands south of Comox was carried out. This survey completed the re-survey of the Strait of Georgia from Comox south.

This year, for part of the time, the REVISOR (under B.M. Lusk) reviewed all charts in the Queen Charlotte Sound area. This completed a revision of all charts of the southern British Columbia Coast (Cape Caution south), which was started in 1969. The remainder of the time was spent on a conventional hydrographic survey of Juan de Fuca and Haro Straits. This survey is being conducted because of the building of a large oil refinery in the State of Washington a few miles south of the U.S.-Canada border. The refinery will primarily be using Alaskan Oil brought to the refinery by giant tankers from the Gulf of Alaska, and the wide channels of Haro Strait and Boundary Pass will become one of the main shipping routes for these tankers to and from the refinery. Consequently an energetic re-survey of the area is being carried out with particular attention being paid to depths up to thirty meters. The survey is on a large scale, 1:25,000, to ensure good coverage, and will be continued in 1972.

On the charter vessel PILOT II (under G.E. Richardson) a detailed survey was carried out on the Mackenzie River from mile 565 to mile 685, and about 322 km of reconnaissance surveys were carried out in the delta channels. This was the first year a vessel had been chartered on the Mackenzie. The work will be continued for the foreseeable future.

The Mackenzie River, though over 1600 km long, has only been surveyed and charted in detail for about 96 km, mostly at the up-stream end. The rest of the river has just been track sounded, and at such a small scale that the charts are not more than maps showing the recommended route. New surveys on the river will be done at 1:50,000. This year strip charts from Fort Simpson to Norman Wells at this scale were published, but these show only track sounding that was done in 1964. It is hoped that strip charts for the remainder of the river to Tuktoyaktuk will be available prior to the 1972 season. Although these strip charts show only track soundings, and there are large gaps in the coverage and many aids to navigation have changed, they are an excellent beginning to modern charting of the river.

Mackenzie River: This view of the Rampart Rapids at a low water stage in the fall shows one of the River's natural navigational hazards. At present only approximately 100 kilometers have been surveyed and charted in detail. Work is continuing on this project each year.

HYDROGRAPHIC DEVELOPMENT GROUP

N. M. Anderson, Head
A. R. Mortimer *
N. S. Fujino *
C. R. Tamasi *

* On "rotation" from Field Hydrography

The Hydrographic Development Group's program for 1971 included:

(1) development of the use of aerial colour photography for hydrography;
(2) writing and cataloguing computer programs for hydrographic computations;
(3) further investigations of inshore positioning systems for hydrographic and other surveys.

A field evaluation of colour photo interpretation of the north-western shore of Georgia Strait was made. Depths were interpreted to 5.48 m, as well as high and low water lines and foreshore characteristics. A preliminary report of this evaluation has been distributed. Colour photography of the Victoria area was flown and mosaics compiled for a 1972 survey. Controlled colour photographic pairs have been supplied to the University of New Brunswick, Department of Survey Engineering,for two media contouring with their analytical plotter. Scientists doing biological and geological research have found these colour photographs to be of assistance in their projects.

Using a PDP/8, a HP 2116 and the University of Victoria's IBM 360, computer programs have been prepared to draw (1) lattices for electronic positioning systems, (2) accuracy contours for these systems and (3) coastlines. The majority of computer programs used by hydrographers have been catalogued and their input/output formats standardized.

An evaluation of the new Trisponder x-band positioning system was completed and a report prepared. Also a further evaluation of the transmission pattern of a low gain omni-directional antenna for the Motorola Range Positioning System was made to define the accuracy limitations of this antenna. A paper was given on inshore positioning systems at the International Congress of Surveyors in Germany.

SAILING DIRECTIONS SECTION

T. Jones, Head
J. W. Chivas

The projects undertaken by this section in 1971 were:

(a) compiling Supplement No. 2 to the "B.C. Pilot" (5th edition), Vol. 2;
(b) compiling Supplement No. 5 to the "B.C. Pilot (7th edition), Vol. 1;
(c) revising the "B.C. Pilot", Vol. 1, in a new format;
(d) collecting and filing material for the compilation of Sailing Direction (Pilots) to complement the new small boat charts for the Gulf area.

New material for the"B.C. Pilot", Vol. 2 involved increasing the size of the previous supplement (they are cumulative) from 11 pages to 24 pages. Much of this new material was gathered on a field trip through the Inner Passage from Vancouver to Stewart in a commercial vessel. The new material for the "B.C. Pilot", Vol. 1 increased the size of its Supplement from 70 to 107 pages.

The revision of the "B.C. Pilot", Vol. 1, is a major undertaking which will result in a virtually new publication with the title "B.C. Sailing Directions". It was undertaken because of the adoption of two new policies. The first requires that information which appears on nautical charts should not be duplicated in their complementary Sailing Directions; this involves a drastic pruning of the present 7th edition. The second policy requires that this publication will in future be printed by a computer-controlled process; this will result in the publication being reprinted annually with all new and changed information spliced into it. This process will eliminate the need for annual supplements which are heartily detested by mariners because of the laborious procedures they involve. Six of the 9 chapters which make up this volume are now in manuscript form.

A new Sailing Directions publication to complement the new small boat charts for the Gulf Islands is the result of a new policy which recognizes the need for charts and sailing directions designed to meet the requirements of the large (and growing) population of small boats on the coast of British Columbia. The collection of information for this publication involves mining an entirely new vein of ore and the preliminary samplings, i.e. questionnaires mailed to marinas, boat works, marine service stations, have already been made. It is expected that a start will be made on the manuscript of this publication early in 1972.

TIDAL AND CURRENT SECTION

S.O. Wigen - Regional Tidal Superintendent

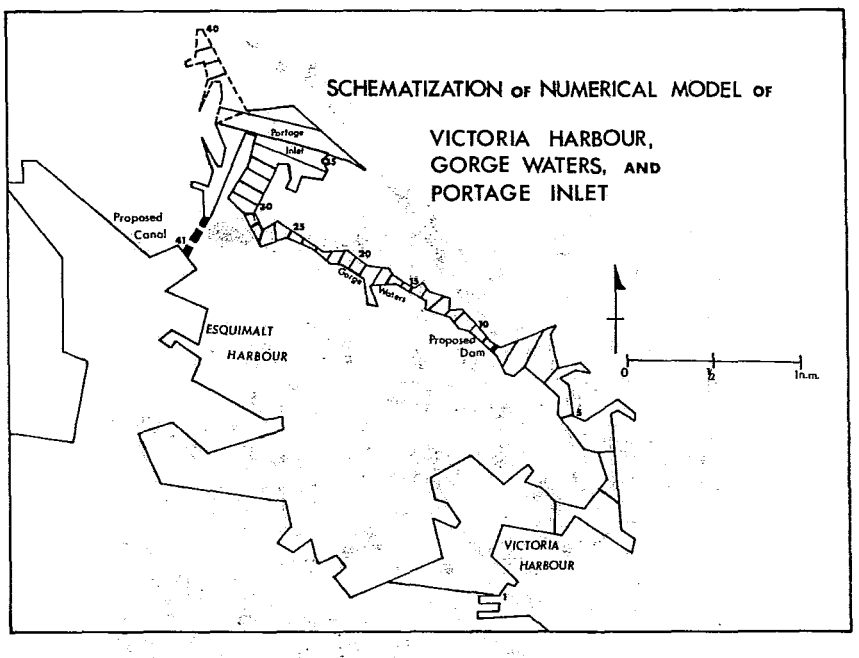
The Tidal and Current Section operates as an integral part of the Canadian Hydrographic Service. Its activities for 1971 are reported here under the four Units of the Section.

Hydraulic Research

A.B. Ages
A.N. Douglas

A one-dimensional explicit numerical model was developed of Victoria Harbour, Gorge Waterway, and Portage Inlet. The model examined the effect of a proposed dam between Victoria Harbour and the Gorge upon the tidal behaviour in the Harbour. It also examined the feasibility of a canal between Portage Inlet and Esquimalt Harbour. The model was calibrated by field measurements of tides and currents and was completed in September.

In the second half of 1971 salinity and temperature measurements were carried out in the Fraser Delta, to study the behaviour of the saline wedge in the Fraser Main Arm and North Arm. The results of these field measurements are to be incorporated in a numerical model of the Delta, which was developed earlier. Additional tests are to be carried out in 1972.



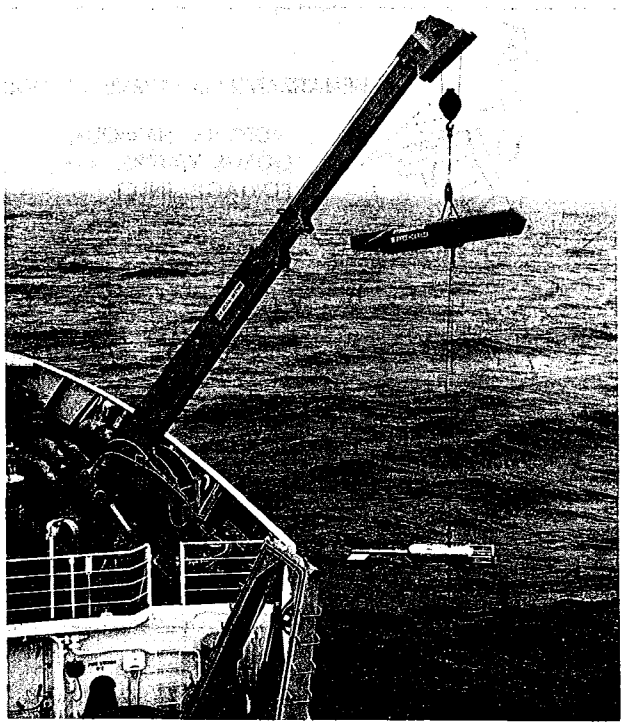
Site of proposed dam on Gorge Waters and canal between Portage Inlet and Esquimalt Harbour. Effects on tidal behaviour in Victoria Harbour have been examined by numerical model.

Current Surveys

J.F. Bath
W.J. Harris
F.V. Hermiston
K. Highton

A tidal and current survey of Alberni Inlet was carried out in the period February to May, 1971. Current meters were placed at seven channel sections for one-month periods to define the principal circulation, with 40 metering stations being occupied. CMDR Neyrpic current meters used for the survey had an operating efficiency of 70%. All meters were recovered-one requiring the services of the submersible "Pisces" when a release mechanism malfunctioned. Drift float observations supplemented the surface measurements.

Recording tide gauges were installed at 11 locations, to define both tidal elevations and seiche waves during the survey. The Alberni Inlet program was carried out in very close co-operation with a research project of the Institute of Oceanography at U.B.C., in which wind and fresh water impounding and discharge were correlated. C.S.S. "Parizeau" and later C.S.S. "Vector" were used. Each week three or four different participants in the Hydrography I Staff Training Program were on board. They did drift-poling in Sproat Narrows, serviced tide gauges, stood a Savonius current meter watch, saw CMDR current meters serviced and were instructed in Satellite Navigation by the Radio Officer.



The Canadian made CMDR NEYRPIC current meter, being used to record current speed and direction in Strait of Georgia survey.

Aanalysis of the current meter records is nearing completion and the results are scheduled for publication in Data Record of Current Observations for Alberni Inlet Volumes VII and VIII.

In conjunction with the Hydrographic Charting of Quatsino Narrows, C.S.S."William J. Stewart" carried out a program of current observations there. Drift floats were tracked for a 3-week period, and the velocities have been correlated with head differences between tide gauges operating at the ends of the Narrows. Flow patterns and velocities before and after slack water are being compiled in a report to aid Pilots in navigating ore-carrying freighters through Quatsino Narrows.

Two current meter stations have been established in the Victoria area, one in Baynes Channel, and the other south of Race Rocks. Up to one year of data is being sought in each location, to form the basis for a new primary current reference station for predictions in Pacific Coast Tide and Current Tables. Some troubles have occurred with the tow lines of tug boats cutting the moorings or dragging the meters out of position. However, initial records have been obtained for harmonic analysis, and the program is continuing into 1972.

Current observations obtained in recent years throughout the Gulf Islands are being compiled, in order to produce a current atlas as an aid to navigation. Additional field measurements needed to complete the atlas are being scheduled for 1972.

Analysis and compilation of the current meter data obtained from major surveys through the Strait of Georgia in 1967 to 1970 are well advanced, and a Data Record will be published.

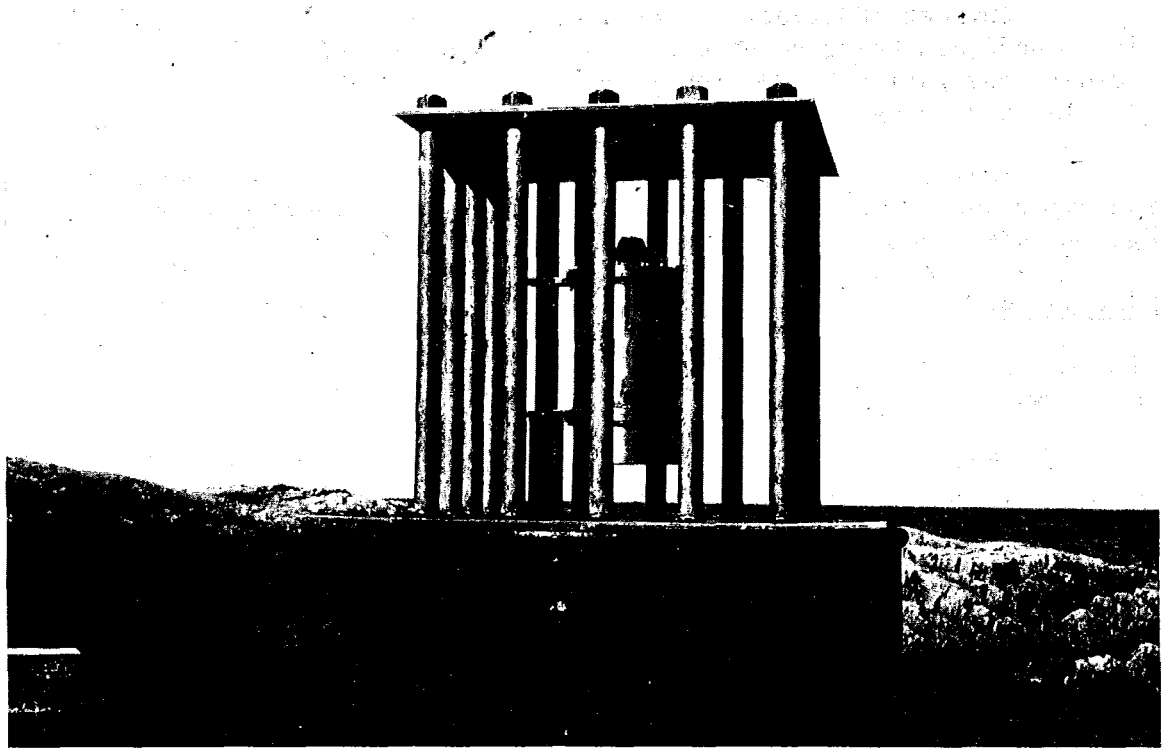
Tidal Survey

W.J. Rapatz
R.E. Brown

This Unit was given the responsibility of arriving at a realistic low water datum in the Mackenzie River for hydrographic charting purposes. Two bubbler gauges were operated in the Mackenzie, and the records from these gauges, combined with the records from gauges operated by Water Survey of Canada, were used to establish charting datums from Great Slave Lake to Fort Good Hope, a distance of about 1,100 km. Preliminary datums were established from Fort Good Hope to the Delta, subject to more information in future years.

Gauge stations were operated at 7 locations in Juan de Fuca and Georgia Straits,continuing the tidal, current, and physical oceanographic study which commenced in 1967. Co-tidal charts of this system are being prepared for publication, and a preliminary draft was supplied to Dr. P. Crean, who has developed a two-dimensional model of the Straits for his thesis at the University of Liverpool.

Teleannouncing tide gauge stations at Steveston and New Westminster were maintained in operation to assist navigation in the Fraser River. The gauges are monitored daily to ensure their accuracy. The teleannouncing gauge at Tofino, which is part of the Tsunami Warning System for the Pacific, was transferred to a new permanent site constructed by Water Survey of Canada. At Langara Island the gauge station was reconstructed. Some problems in the transducers and in the radio transmission have been experienced at this isolated site, but it is hoped that during 1972 the station can become a new and important link in the Tsunami Warning Net.



Transducer for Langara Island teleannouncing tide gauge, mounted in new stainless steel cage.

Tidal Survey continued to provide a variety of essential services. Hydrographic field parties for the Pacific and western Arctic Regions were supplied with gauging equipment and vertical control data. Tidal and current information for Hydrographic charts were constantly updated. Recent tidal analyses were reviewed for revision of the Secondary Port listing in Tide and Current Tables. Tidal and current information for the B.C. Pilot is being rewritten. Each day brings a wide variety of requests for information from mariners and boat operators, scientists or consulting engineers, and the public.

Helicopter support, provided by Polar Continental Shelf Base at Tuktoyaktuk for tidal survey of Eskimo Lakes, N.W.T.

Data Processing

B. Stenning
L. Ponse

The Data Processing Unit processed all Marine Sciences Branch tide records for the Pacific and western Arctic regions, and forwarded the data to Ottawa for analysis and inclusion in "Water Levels Volume 3". All records were submitted in the form of punch cards ready for computer processing, and consisted of hourly tide heights, high and low water times and heights, and monthly extreme tides.

The Unit performed other support services, keypunching computer programs and a variety of data, and verifying all Chart Distribution keypunching.

A large backlog of current meter data from 1969 and 1970 current surveys in the Strait of Georgia, and from 1970 and 1971 current surveys in Alberni Inlet, were translated into vectors and placed on magnetic tape with the Tidal and Current Section's Hewlett Packard computer. After considerable editing Alberni Inlet data were processed at the University of Victoria to produce speed-direction diagrams, daily residuals and harmonic constants. During 1971 the Section's computer capability was increased, with the acquisition of an 80-column Versatix matrix line printer, and a 9-track magnetic tape unit to interface with the Hewlett Packard 2116 B computer.

In May the Section was connected to the Computer Sciences of Canada Ltd. time sharing system with an ASR33 model teleprinter as our terminal.

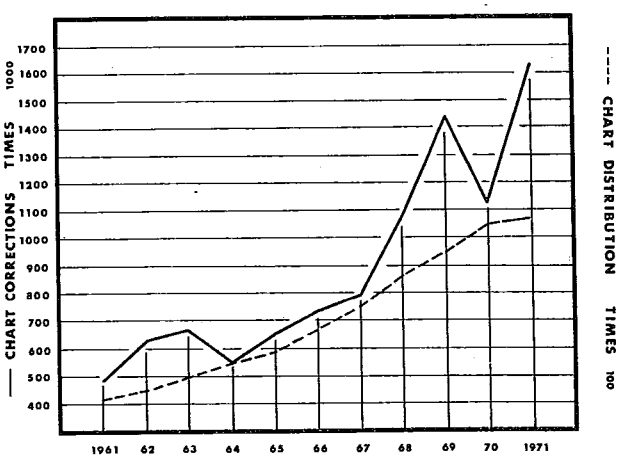
CHART CONSTRUCTION

F.R. Smithers, Head
R. Banyard
R.D. Bell
P.C. Browning
D.J. Clark
J.H. Coldwell
E.M. Colter
D.G. Dobson
K.R. Holman
A.G. Lyon
T.M. Mani
C.J. Nast
M.M. Patton
T.C. Plume
M.S. Taylor
L.G. Thomson
V.N. Young

This Section is responsible for the compilation, revision, correction and distribution of the Pacific Region charts and publications. In addition, illustration drafting, photographic and printing services are provided for the Region.

The primary activities of the Section have been to compile new charts from new surveys, revise existing charts from new information, hand correct published chart stock from Notices to Mariners and distribute these charts to the public.

During 1971 Chart 3400 was compiled at a scale of 1:160,000 and Chart 3310 at 1:40,000. The first Pacific Region small craft chart, which is in 4 strips covering an area from Victoria to Nanaimo and including the waters of the Gulf Islands, has also been compiled. Prince Rupert Harbour, Chart 3701, and Venn Passage, Chart 3703, have been scribed and are in the final stage of checking. A total of 14 other charts were revised for new editions, most of the information being obtained as a result of field revisory surveys.



The number of charts corrected and distributed has continued to grow. The dip in corrections in 1970 was caused by a temporary move of the Section.

A total of 107,777 charts were distributed from the office during the year. These charts required 1,269,715 hand amendments in order that they become updated prior to distribution. Over 17,000 copies of nautical publications including Tide Tables, B.C. Pilots, Light Lists and Radio Aids were also distributed.

There are 161 chart dealers on and around the Pacific Coast and, of these, 34 were inspected in 1971. Inspection takes the form of certification of all stock and the cancelling of outdated charts. Because they failed to meet dealer standards, 12 dealerships were cancelled. Eighteen new applicants were granted dealerships.

Nautical chart displays were manned in Seattle and Vancouver. The section compiled all land and bathymetric contours for a relief model of the Strait of Georgia at a scale of 1:80,000. This large model will be displayed by the Department of the Environment in the 1972 Vancouver Boat Show and later at other public shows.

SURVEY ELECTRONICS

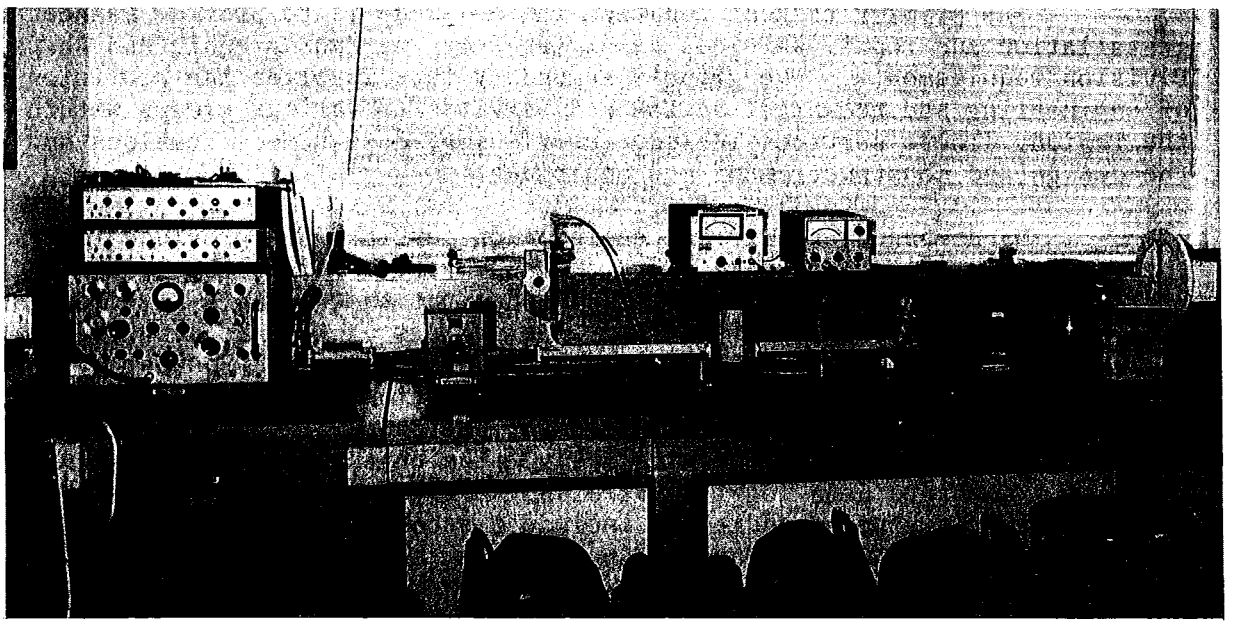
J.V. Watt, Head
C.F. Ryan
J.S. Rainko
W.R. Taylor
J.S. Wallace
T.J. Soutar

The primary task of the electronics group is to provide maintenance, installation and repair services as dictated by the Hydrographic and Ships Division requirements. The group's secondary task involves the provision of engineering and technical advice and services to various groups within the region. These services include interfacing, design modifications and the design and construction of new equipment.

Maintenance, repair and calibration services are provided for the wide variety of electronic equipment and systems in use aboard the Region's four major ships and twenty launches, at the Region's Electronics Laboratory, in the field, and at sea. The various equipments serviced include HF and VHF Communications Equipment, Sonar and Echo Sounder Systems, Ships Radar and Navigation Systems, Precise Positioning Systems, Data Acquisition Systems, Computers and Computer Peripherals. The maintenance requirements have increased significantly in the past year with the acquisition of a complete data logging system and a PDP 8/e computer processing system. Other equipment additions include a second Motorola Range Positioning System (R.P.S.) and an increase in the number of echo sounder and radio telephone units.

The major changes brought about in the area of maintenance during this past year involved the calibration of echo sounders and the maintenance of the R.P.S. A re-evaluation and subsequent alteration in techniques employed in the calibration of echo sounders and a major effort to improve and standardize maintenance procedures applied to the R.P.S. were undertaken.

Design projects involving the group over the past year include the design and construction, in association with others, of the hardware and software required to interface a Ross Laboratories Data Acquisition System to the M.S.B. PDP 8/e to produce a system capable of plotting bathymetry on-line. Other projects involved the design and construction of an interface board for operation of the C-Tech depth digitizer with a Ross 400 Fine Line recorder and the redesign and construction of a Bedford Institute designed LPD 111 Matching Unit to allow operation of the BIODAL System with an LPD 401 digitizer unit. Modifications, in accordance with Bedford Institute specifications, were completed this year on the Alpine "PESR" Sounder Recorders to permit operation of these units under control of the BIODAL digital clock.



Test Equipment set-up as applied in the tuning of the Motorola Range Positioning System (R.P.S.) X-Band Radar Transponders.

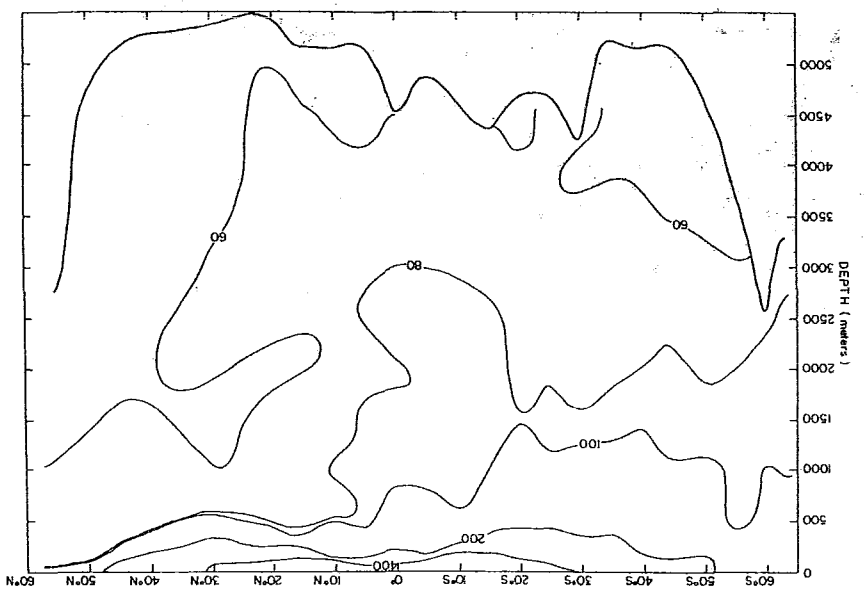
OCEAN CHEMISTRY DIVISION

C.S. Wong, Head
R.D. Bellegay
P. Vandergugten

The main activity of the Division of Ocean Chemistry in 1971 was on setting up the organization: this included defining our direction of research, recruiting technical and scientific staff and planning the budgetary and space requirements. Facilities were being acquired to equip 65 m^2 of laboratory space (radiocarbon dating) in B.C. Research and about 195 m^2 of office, storage and laboratory space (oceanographic, carbon dioxide, trace element and hydrocarbon laboratories) in the MSB Depot in Victoria. Limited by the small size of the staff and the heavy administrative duties associated with the early stages of development of a newly set-up division, the scientific activities could only be focussed on processing the HUDSON-70 data for publication and station "P" chemical data for a review and adjustment of on-going weathership chemical program.

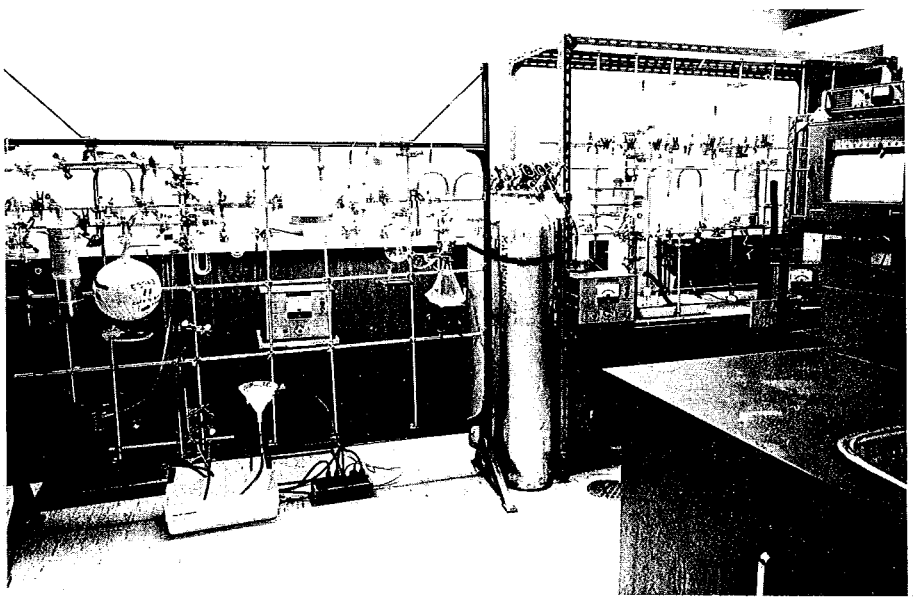
HUDSON-70 data. IMB-1130 programs to calculate carbonate chemistry parameters from thermodynamic relations were written to process the shipboard potentiometric titration data. A paper is being prepared on the alkalinity and another on the saturation depth of calcium carbonate in the Pacific Ocean. The dissolution of calium carbonate is a major geochemical problem. It is important in the buffering mechanism of the ocean, which, as is discussed below, influences atmospheric CO_2. Our calculation of the degree of saturation of calcium carbonate in the Pacific shows that a larger volume of the ocean is undersaturated than previously thought.

Nutrient Chemistry. Daily collection of sea water samples in the surface layer at station "P" was made for auto-analyses of phosphorous, nitrogen and silicon to meet the requirements of F.R.B. and other biological users of station "P" data, and to supply background information for other programs, such as the marine carbon budget study.



DEGREE OF SATURATION OF CALCIUM CARBONATE IN THE PACIFIC ALONG 150°W based on thermodynamic relations and HUDSON-70 alkalinity and total CO_2 data. The 100% line separating the upper supersaturated water from the lower undersaturated water, is about 1000 m. deep in the southern hemisphere and less than 500 m in the north.

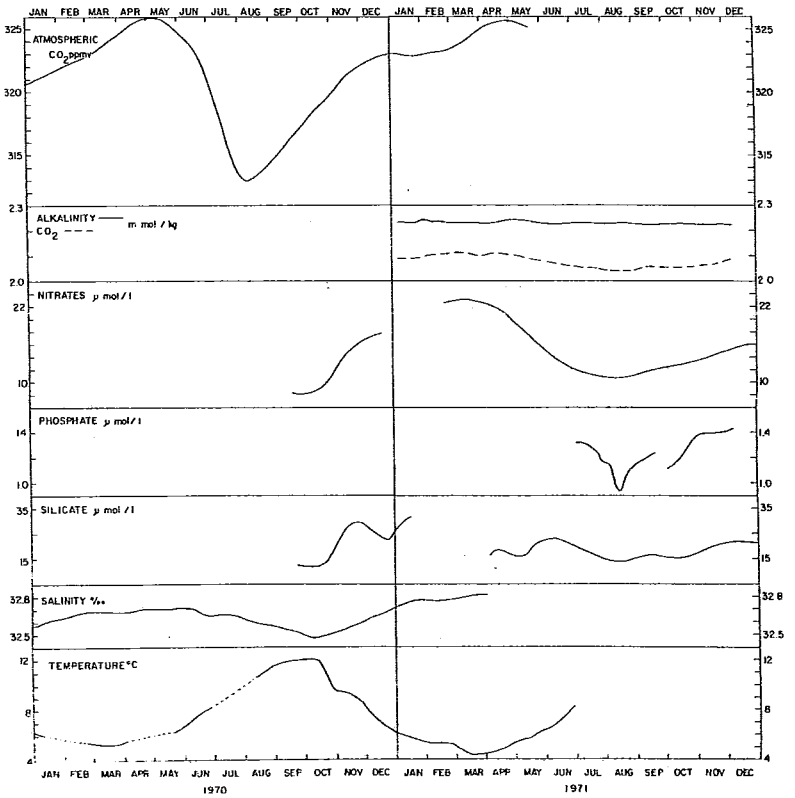
Marine Carbon Dioxide Budget. Concern about the atmospheric CO_2 increase and its possible climatic effects has brought about an expansion of interest in the study of this subject from the geophysical field into the environmental area. To date, the quantitative aspects of the atmospheric CO_2, such as the seasonal variation, long-term upward trend and year-to-year variation in the rate of increase, have been reasonably well established through the efforts of Keeling's group at the Scripps Institute of Oceanography in the U. S. A., and of Bolin's group at the Meteorological Institute in Sweden. There is a crucial lack of knowledge of the role of the ocean. Is there a year-to-year change in the ocean's capacity to absorb atmospheric CO_2? Which factor is most important in controlling the air-sea exchange coefficient: turbulence, the marine biosphere, or the carbonate chemistry? Is there a seasonal change in the air-sea exchange rate? Answers to these questions are needed critically in formulating any successful predictive model of future atmospheric CO_2. The manning of the Canadian weathership at ocean station "P" (50°N, 145°W) has offered us a unique strategic advantage in embarking on a major chemical oceanographic effort on such a long-term study of a significant environmental problem.



INFRA-RED GAS ANALYZING SYSTEM for atmospheric CO_2 and oceanic CO_2, with a precision of ± 0.1 ppm. is the only high precision CO_2 monitoring system in Canada.

In 1971, an exploratory study of the oceanic CO_2 system was made at station "P" using potentiometric titration techniques to obtain alkalinity and total CO_2 from $HgCl_2$- preserved samples. In the chemical data processed so far, the alkalinity is surprisingly constant while the oceanic total CO_2 changes by about 2% in an annual cycle. The atmospheric CO_2, oceanic total CO_2 and nutrients in surface waters show an annual cycle with winter maximum and summer minimum. These observations suggest that the marine biosphere may play a more important role than has previously been thought, relative to the buffering capacity of the sea water in regulating the atmospheric CO_2 budget at station "P". Our effort in 1972 will be expanded to start a time-series on partial pressure of oceanic CO_2 and air-sea C14 exchange at station "P".

Much of the work done in 1971 was devoted to instrumentation: (a) radiocarbon dating facilities to be set up in B.C. Research, (b) construction of two p_{CO2} equilibrating systems and (c) an infra-red gas analyzing system set up already in Nanaimo. About half-a-year was spent on setting up (c) and its subsequent testing, and its precision achieved is about ±0.1 p.m. through inter-calibration of reference tank gases with Scripps. This precision is comparable to similar systems at SIO, NCAR and the Swedish Meteorological Institute and our atmospheric CO_2 values will be tied to this global network for consistency and inter-comparison of results. Our system will be used for shore-laboratory analysis of atmospheric CO_2 extracted from surface water samples collected at station "P" and from other cruises.



TIME SERIES OF CHEMICAL DATA AT STATION "P". Weekly observations of atmospheric CO_2, oceanic total CO_2 observed at 3-day intervals and daily nutrients show an annual cycle with winter maximum and summer minimum. On the other hand alkalinity, observed at 3-day intervals, is essentially invariant. This suggests a possible significant role of the marine biosphere in regulating atmoshperic CO_2 and oceanic CO_2.

OCEAN PHYSICS DIVISION

P. W. Nasmyth, Head

The Ocean Physics Division has a total of 35 full time continuing scientific and technical personnel in four locations in and around Victoria, and including a group of 11 at the Fisheries Research Board's Pacific Environment Institute in West Vancouver. The program of the division covers a wide variety of subjects in physical oceanography and ice physics, with activities ranging from the coastal waters of British Columbia to the offshore waters of the northeast Pacific and Gulf of Alaska and the Canadian Arctic Archipelago.

The work at the MSB Pacific Oceanographic Section, attached to PEI in West Vancouver, is an integral part of the Region's program, but that section, as a major responsibility, provides physical oceanographic support for the Fisheries Service projects on pollution problems undertaken by PEI.

A study has been undertaken by contract of the application of "remote sensing" techniques in oceanography and hydrography as they may now or in the future, affect the activities of the Marine Sciences Branch.

The activities of the different elements of the Division are reported separately.

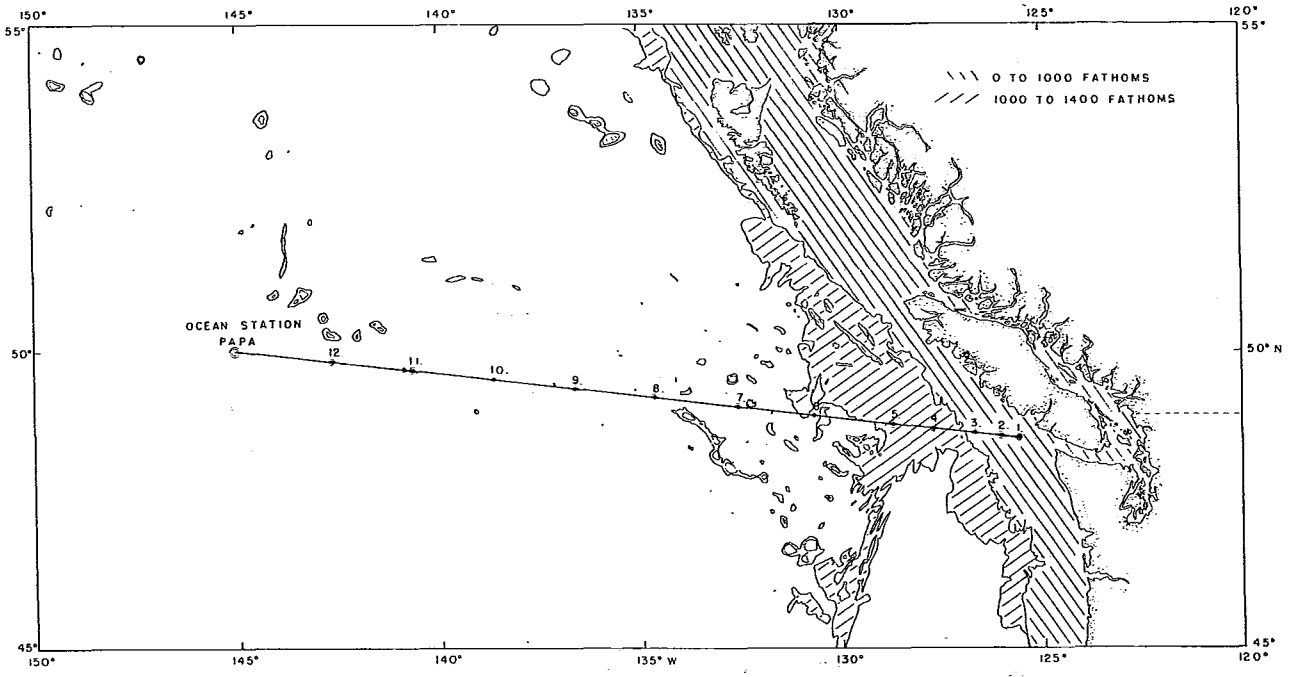
OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett, Head
S. Tabata *
R.E. Thomson *
D. Healey #
D.B. Smith
K.A. Abbott-Smith
C. de Jong
B.G. Minkley
W. Hansen *

* joined during 1971
\# left during 1971

The group is responsible for the study of oceanic water motions and modifications to ocean water properties arising from physical processes with emphasis on those regions and processes affecting Canada's Pacific and Arctic coasts. Following are capsule descriptions of our major undertakings during 1971.

Weathership Oceanography. The oceanographic time series started in 1956 at Ocean Station P (50°N, 145°W), which includes weekly water samples from 27 levels between the surface and bottom, twice weekly STD casts and various other biological and chemical sampling, and the "Line P" series of 12 stations between Esquimalt and Ocean Station P, were continued during 1971. Personnel from Offshore Oceanography manned six patrols and technicians from Ocean Chemistry two, leaving only one of the nine weathership patrols without an oceanographer aboard.



LINE P, SEA MOUNT RIDGE AND CONTINENTAL SHELF

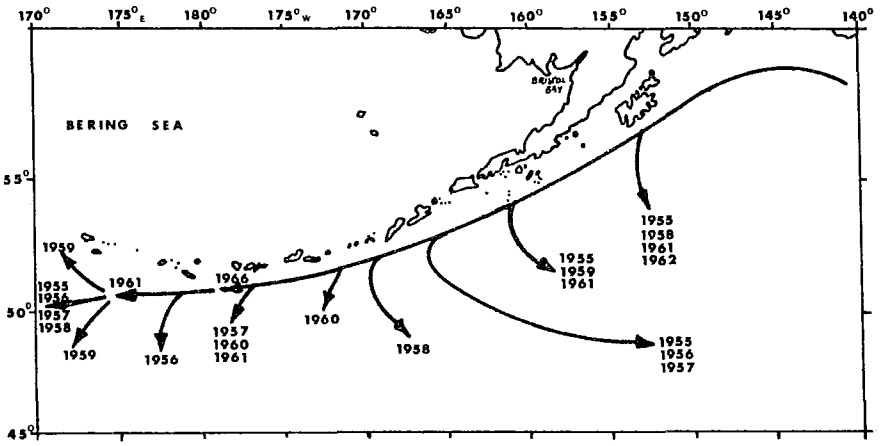
Line P stations 1 to 12 at which oceanographic observations are made to and from Ocean Station P.

The bottom topography, as indicated by the shading of depths less than 2500 m, may be the cause of increased variability in the surface water properties in the eastern half of Line P due to trapping of Rossby-topographic waves between the sea mount ridge and the coast.

One purpose of this program is to monitor variations in water properties and other indicators both to get an idea of the naturally present variability and to detect unusual events. Another is to provide data for the study of relationships between various quantities such as sea bird populations and water properties or as background for samples which are only occasionally taken, such as the mid-water trawling carried out in 1969 and 1971 by Dr. C. Gruchy of the National Museum. To enable investigators in other institutions to take advantage of this work, all oceanographic data is published and distributed in the form of manuscript reports. Six new volumes were added to this series in 1971, bringing the total to 50. In addition substantial progress was made in developing a computer accessible magnetic tape archive of all observed data to simplify the preparation of statistical summaries. (Garrett).

Ocean Climate Fluctuations. Various attempts to account for warm and cold years in the North East Pacific have been made in the past. The latest, which relates the distribution of wind stress curl to the strength of the Alaska gyre, shows encouraging qualitative agreement with the data available. However, in spite of the fact that the North East Pacific has been the subject of more systematic survey cruises than almost any other oceanic area, quantitative comparisons are still almost impossible because of the shortage of suitable oceanographic data. (Thomson).

Alaska Stream Separation. The Alaska Stream offers a unique example of a western boundary current following a boundary (the Aleutian Arc) along which the Coriolis parameter decreases at first as the boundary tends south and then increases as the boundary turns north. A linear theoretical analysis shows that the point of separation of the stream from the boundary is controlled by a balance between the local input of vorticity by the winds and the rate of loss of vorticity to the boundary in the zonal region of the coast. This seems to be supported by the limited data available. (Thomson).



ALASKA STREAM

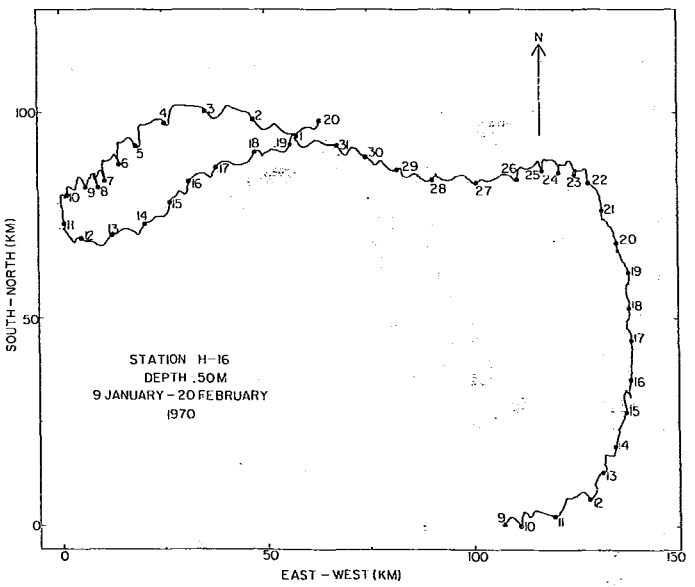
Locations at which surface salinity distributions have indicated southward branching from the Alaska Stream in various years. A new analysis of the dynamics of this flow indicates that the point of separation is controlled by the distribution of winds over the Gulf of Alaska.

Planetary Waves and Fluctuating Geostrophic Currents. Water temperatures at a depth of 3 meters along the eastern half of Line P seem to show a wave-like motion which is persistent in time, as was first noticed by Fofonoff and Tabata in 1966. As this half of Line P lies over a deep water basin between the continental shelf and a sea mount ridge, one suggested explanation was that these long period motions could be due to planetary waves trapped in this basin by the sea mount ridge. Theoretical calculations show that the majority of energy associated with barotropic planetary waves having eastward group velocity (towards the B.C. coast) is reflected by the ridge if the wavelength is less than about 2000 km, while the majority of energy of waves with westward group velocity is reflected if wavelength is less than 4000 km. The ridge therefore is more penetrable for waves of a given scale generated to its west than to its east. Also, an initially eastward propagating wave passing over the ridge could be trapped after it was reflected from the B.C. coast.

This leads to an expectation that the amount of energy associated with such waves--which have the character of variable current systems--will be greater on the east side compared to that on the west side.

A new analysis has been done using sea surface temperatures in the vicinity of Line P obtained from ship intakes to see if the apparent large variability over the basin persists when more data is used. These new statistics indicate that it does, but that it is not so striking as in the earlier data. (Thomson).

Variability of Current Velocity and Water Temperature in the Strait of Georgia. In 1969, while the investigator was employed by the Pacific Oceanographic Group, Fisheries Research Board of Canada in Nanaimo, B.C. he embarked on a program of current velocity observations in the Strait of Georgia with the primary objective of obtaining data with sufficiently high frequency and of sufficient length to examine the spectrum of the variability of current velocities in the frequency band between 1 cycle and 10^{-3} cycle per hour (period of an hour to few months) at a representative area of the central Strait. Such data are expected to provide, in addition to basic scientific information, solid background material that would be useful in a variety of applied oceanographic studies associated with pollution and fisheries.



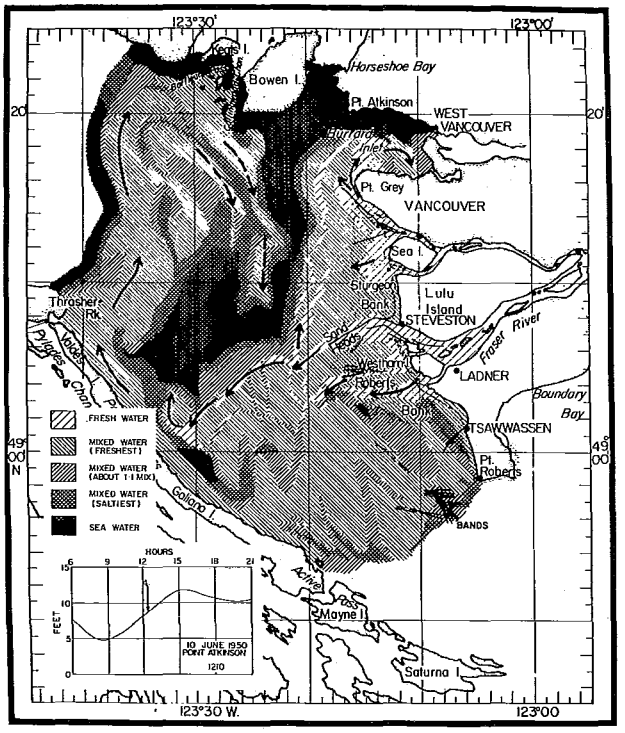
An example of current velocity obtained at 15-minute intervals for a period of 6 weeks at 50m-depth in the middle of the Strait of Georgia. Tidal currents are evident as noted in the zig-zag presentation in the line but appreciable non-tidal currents occur. During the first few days the currents flow eastward, then for the next 10 days they flow northward, followed by 19 days of westerly flow; a reversal in the current directions occurs and the currents flow eastward for the next 9 days. This example shows the importance of long series of measurements particularly in applied problems such as when information is sought for the proper selection of sewerage outfalls.

The data collected over one year during April 1969 through September 1970 in a line of 3 stations between Valdes Island and Point Grey have been processed to the point that they are available in summarized form and in detailed recorded format. Detailed analysis of the data has not begun but it is planned to compute spectra for each set of measurements

(3 weeks to 6 weeks length each), compute cross spectra for each pair of sets of measurements to examine the coherence in the data, and to examine spectra of the lower wind velocities, as well as barometric pressures and sea level heights in the vicinity (offshore as well as inshore). (Tabata)

The Movement of Fraser River-influenced surface water in the Strait of Georgia as deduced from a series of aerial photographs. Two decades ago an aerial survey along the eastern side of the central Strait of Georgia was made to aid the interpretation of surface water movements therein so that the information could be used to assist the Greater Vancouver Sewage and Drainage District in selecting a proper site for their effluent discharge. An attempt to exploit further the information contained in the series of photographs has been made, in view of the fact that the movement of water in the area has become more important in recent years.

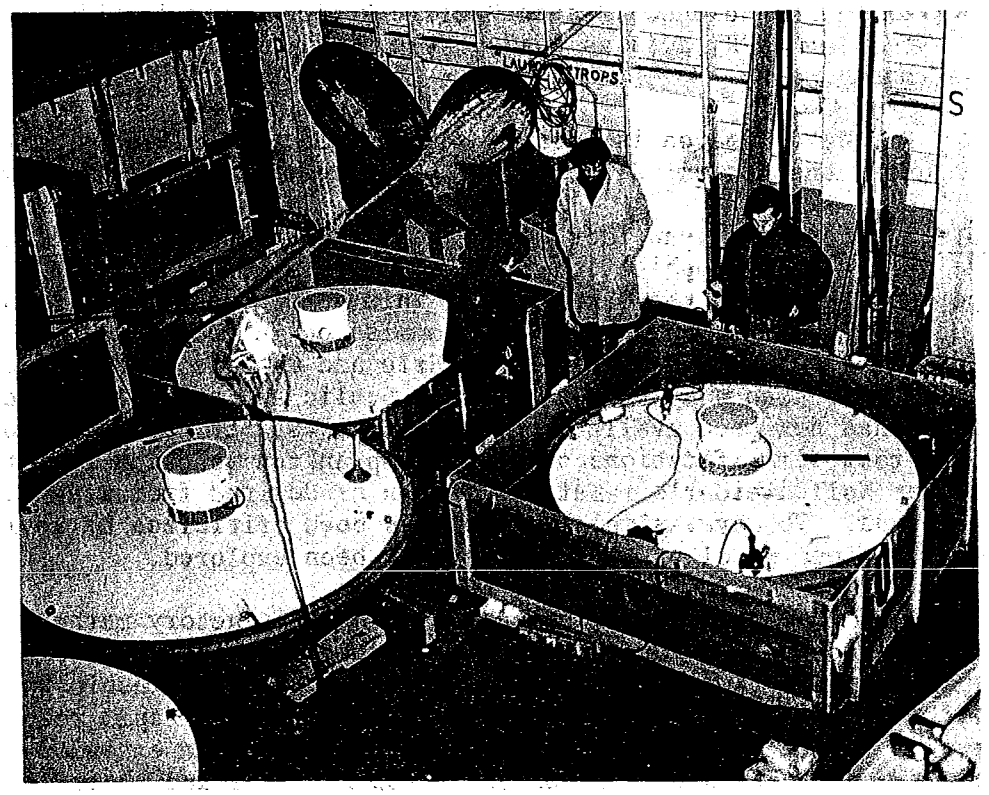
Analysis of the data is completed and a suitable report is being prepared. One of the principal results of the analysis has been the detection of the Fraser River plume which flows as a concentrated jet toward the Gulf Island, veers to flow northeastward, as far as Bowen Island, then further veers to flow southward. (Tabata).



FRASER RIVER PLUME

An example of surface water movement deduced from a series of aerial photographs. Note the presence of a well-defined Fraser River jet emanating from the mouth of the main arm of the Fraser River. The jet-like plume extends to the vicinity of Galiano Island and appears to continue northeastward forming a clockwise "loop" that carries the river water as far northward as Bowen Island and then veers to the south. The arrow on the tidal curve indicates the state of the tide at which this movement pattern occurred.

EOLE Buoy Experiment. This experiment, in which Offshore Oceanography is cooperating with the Laboratoire de Météorologie Dynamique of the French Centre National de la Recherche Scientifique, is intended to study the variations in ocean surface currents over distances of a few kilometers by means of drifting buoys which will be tracked from the EOLE satellite. Ten buoys are to be launched near the end of January 1972 at about 40°N, 150°W in two clusters of five buoys each. Within each cluster the buoys are to be separated by about 1 kilometer, while the clusters will be separated by 60 km. The buoys were assembled and tested electronically by an engineer and technicians from France during December in the Marine Sciences Branch Depot. (Garrett).



C.N.R.S. (France) drift buoys being readied for sea in Marine Sciences Branch Warehouse in Victoria, B.C. Ten buoys are to be set out in the North Pacific and tracked by means of the EOLE satellite.

Coastal Dynamics. A tongue of relatively warm water appears annually off the B.C. Coast, but its northward extent varies greatly from year to year. A possible explanation has been found in variations in the onshore Ekman transport and the relative warmth of the upper oceanic layer in winter. (Thomson).

OCEANOGRAPHIC SECTION, WEST VANCOUVER

W.M. Cameron - Senior Research Associate

A.J. Dodimead (FRB) - Acting Head
P.B. Crean - educational leave
L.F. Giovando
W.H. Bell
R.H. Herlinveaux
H.J. Hollister
J.A. Stickland
J.H. Meikle
R.H. Bigham
K.A. Gantzer
R.E. Forbes

The Marine Sciences Branch Pacific Oceanographic Section West Vancouver has as a major responsibility the provision of physical oceanographic support to the environmental studies of the Fisheries Service Pacific Environment Institute. Program planning and direction is done from Marine Sciences Branch Pacific Region Victoria while Mr. A.J. Dodimead (FRB) acts as head of the section for communication and local management.

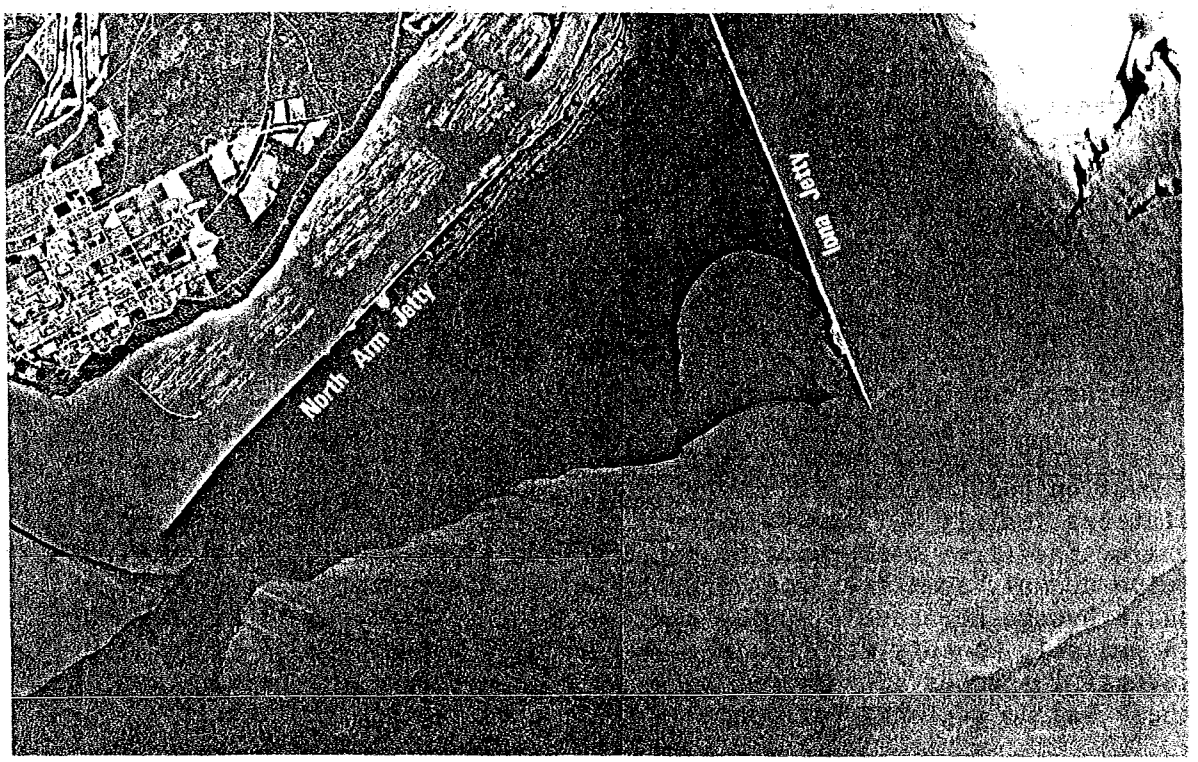
Dr. W.M. Cameron is located with the Section where he conducts research under the general direction of the Director MSB Pacific Region.

Phosphate Studies. Wollenweider (1968) has demonstrated statistically that the degree of eutrophication in lakes is related to the phosphate input per unit area and the lake depth. This demonstration was heavily relied upon by the International Joint Commission in recommending a reduction in phosphate input into Lakes Erie and Ontario. The causal relationship has been a mystery to the lay public and a quantitative explanation has not been available to limnologists. It has been shown, by making gross simplifications of the phytoplankton reaction to nutrient supply, that Wollenweider's relationship can be derived from kinematic considerations. The over-simplification has been criticized by reviewers and a more refined model of this process has been explored.

Until the present, there has been no satisfactory method of predicting the phosphate concentration in a lake in relation to a change in phosphate input. A simple model to suggest this relationship was developed in 1968 and the possibility of an unexpectedly rapid response to change in supply was apparent. The model has now been extended to include seven parameters bearing on this response rate and their effect in various combinations is being investigated. (Cameron).

Arctic Studies. Recent requirement for more thorough examination of Arctic oceanographic data have led to a proposed collaboration with R.H. Herlinveaux. It is intended that the two of us prepare an oceanographic atlas of the Arctic summarizing graphically all presently available data and make an attempt to describe the processes which affect the oceanographic variables. The research program will involve the examination first of those regions in which the data are most numerous both in space and time. The features and their variation will be reported and attempts will be made to deduce the probable range of variation which might be expected. (Cameron).

Strait of Georgia. In conjunction with S. Tabata, an examination of the current regime in the immediate vicinity of the Iona Island sewerage outfall, servicing Vancouver, B.C. has been completed. In the absence of wind, surface currents were generally between $\frac{1}{2}$ and 1 knot. The surface movement was predominantly northward in a narrow (approx. 3 km wide) strip immediately offshore. Seaward of this, overall southerly movement was indicated to persist, at least for periods of a few days. Thus, contrary to general belief, a net northerly flow does not exist at all times within the eastern half of the Strait of Georgia.



Aerial photograph showing Fraser River Plume, delineated here by bands of lighter coloured water.

Also, there is some evidence of a surface "microcirculation" which can at times move effluent from the sewerage channel onshore north of the neighbouring impermeable jetty (which was constructed to prevent such movement). The sub-surface motion a few kilometers offshore is mostly easterly but sometimes northerly, speeds generally being between 0.1 and 0.5 knots. The study demonstrates that detailed knowledge of the flow at all depths within the area is still meagre. It is also generally indicated that effluent from the outfall can (albeit in a diluted form) move onto the shore of Burrard Inlet and southern Howe Sound. (Giovando).

Current data in the general area suggested for an outfall in the Five Finger Island area--to service a proposed expansion of the Nanaimo, B.C. sewerage-processing system--have been obtained and are being analyzed. It appears that the subsurface net movement, both at the outfall "site" and somewhat to seaward, is strongly easterly in direction, over periods of about 6 to 7 weeks at least. The motion is generally somewhat south of east; if the flow persists in this fashion to the east of the sampling sites, it could impinge upon western Gabriola Island. Some north-of-east motion is also apparent. Fundamental diurnal or semi-diurnal tidal effects are not strongly in evidence. The average net flow is of the order of 15 to 20 km per day over a 6 to 7 week period. However, short periods (of a few days duration) featured by very restricted net movement can occur. Surface net movement, although somewhat more irregular in its major features, also appears to be easterly in direction. (Giovando).

A general survey was undertaken of problems relating to thermal effluents discharged into coastal waters, and a program of temperature and current measurements is underway in Burrard Inlet, adjacent to an existing thermal-electric generating plant. A mathematical model is being developed for studying the dispersion of various contaminants and tracers.

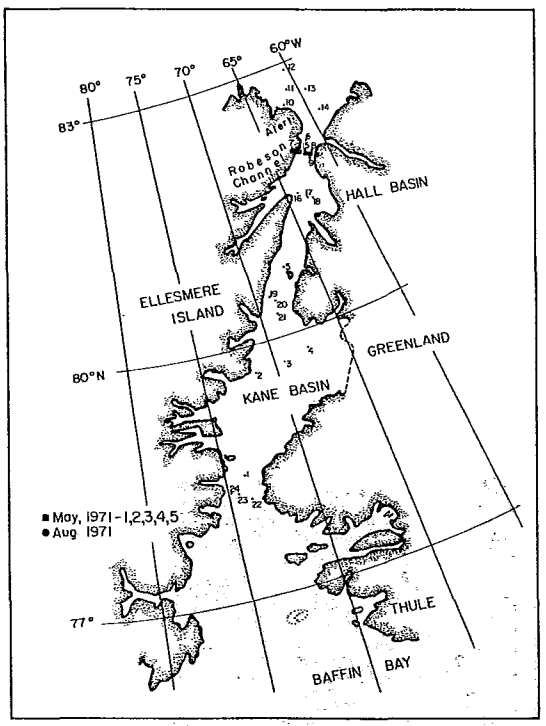
A program of measurements has been initiated to examine the physical oceanographic features of Howe Sound, a fiord-type estuary adjoining the Strait of Georgia. Two current-metering buoy arrays have been established there, and a series of line and anchor stations will be taken. Near-shore currents at PEI are also being studied. (Bell).

Daily surface oceanographic observations. Again in 1971, daily surface observations of temperature and density were made at high tide at 17 shore stations (mainly MOT lightstations) along the British Columbia coast. During the first 6 months, the monthly mean sea temperatures were generally below normal, sometimes considerably below. Below normal temperatures again became noticeable during the last 3 months, especially in December. In general, monthly mean salinities were near normal during 1971. The several instances of abnormal means were more frequently below normal but there was no regional coherence in their occurrence. (Hollister).

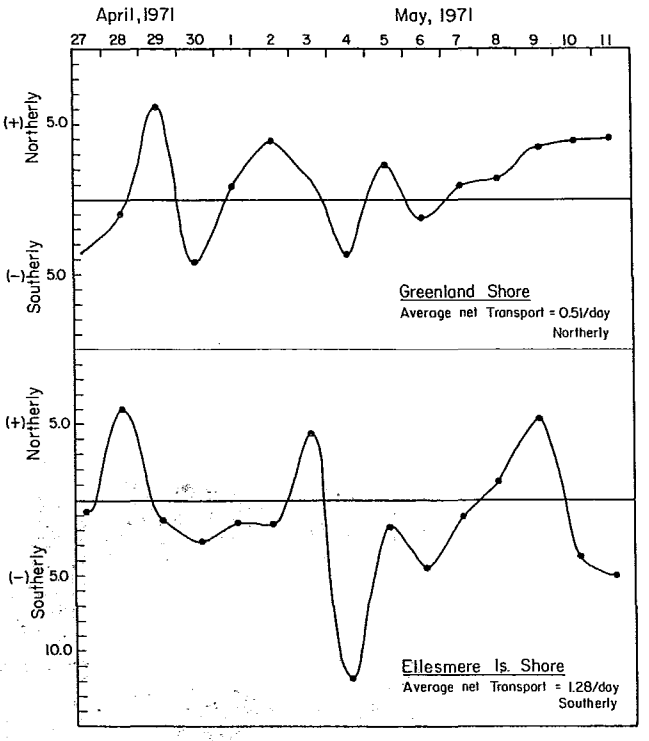
Estuarine Oceanography. Studies on estuarine circulation and mechanisms were continued in Alberni Inlet. A year of continuous observations of currents, water temperatures and winds was completed in June 1971. There data were collected to determine the resident time of surface waters and for heat budget studies. Analysis of the current data from Port Alberni harbour shows that the computed daily net transport varies both in magnitude and direction. The net movement in mid-channel was "inward"; the net movement on the harbour (east) side, was "outward". The magnitude of the net movement fluctuates seasonally, with maximum in May/June and a minimum in November/December. (Herlinveaux).

Arctic Oceanography. Oceanographic programs were carried out during both spring and summer 1971, in the channels between Greenland and Ellesmere Island. The spring program (April/May) consisted of a 15-day series of current measurements on each side of Robeson Channel and included periodic current-profile and time-series observations at mid-channel. Oceanographic stations were also taken across the channel in the same area.

The summer program (August) consisted of longitudinal and cross-channel sections of oceanographic stations from Baffin Bay into the Lincoln Sea, observed from CCGS LOUIS ST. LAURENT. The Robeson Channel cross-sections taken in the spring were repeated.



Location of 1971 oceanographic observations in channels connecting Arctic Ocean and Baffin Bay.



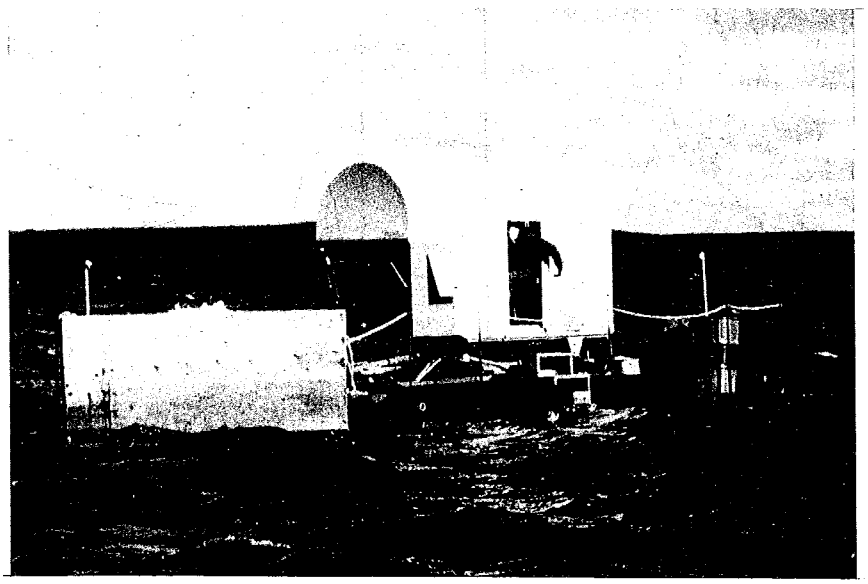
Net transports in Robeson Channel based on current measurement in April and May 1971.

Robeson Channel. Currents at 5-meters depth in Robeson Channel are markedly rotary. The average net transport for the 15-day period on the east side of the channel was 0.82 km per day to the north while on the west it was 2 km per day to the south. Because of the ice cover (average thickness of 2 m) the cause of the oscillatory nature or the movement is not considered to be related to local winds; it is possibly due to the passage of weather systems to the north and south of Robeson Channel. Further analysis of these systems and of sea-level data collected at Alert and stations to the south, will be carried out.

The vertical current profiles observed under the ice at mid-channel suggest that surface movement observed on either side of the channel may be representative of movement to depths of 50 meters (the bottom of the upper zone) or even deeper.

Baffin Bay - Lincoln Sea. Tentative results show that there are cloud-like movements of water in the column which can be identified by maxima and minima in the temperature structure. The surface salinity distribution suggests that low-salinity water, resulting from local run-off, moves north along the Greenland shore and south on the west side and in mid-channel. Ships' drift in mid-channel was observed to be about 1 knot southerly. Analyses of the data are being compiled for publication.

A hydrographic sounding program was carried out through the area as the ship proceeded to the Lincoln Sea and on the return. The sounding tracks and records were turned over to the Hydrographic Service. (Herlinveaux).



Frozen Sea Research Group oceanographic sled on the raft in Cambridge Bay. (Sept. 1971).

OCEAN MIXING SECTION

P.W. Nasmyth, Head
A.E. Gargett
G.W. Chase
R.C. Teichrob

The long term objective of the Ocean Mixing program is to develop our knowledge and understanding of turbulent mixing, in both coastal waters and deep ocean areas to the extent that we can calculate rates of transport and dispersion and attempt quantitative predictions. The factors to be predicted are the vertical transports of heat and energy and their effects on energy interchange with the atmosphere at the sea surface; and the transport and dispersion of either pollutants, nutrients or other contaminants of interest to marine ecologists.

It was reported a year ago that major responsibility for the Ocean Mixing program had been taken over from the Defence Research Board during 1970. DRB continues to support the program by contributing ship time, computer services and some of the facilities and highly developed engineering skills of DREP. A profitable overlap and interchange of personnel between this program and the DREP Fluid Dynamics Group also continues.

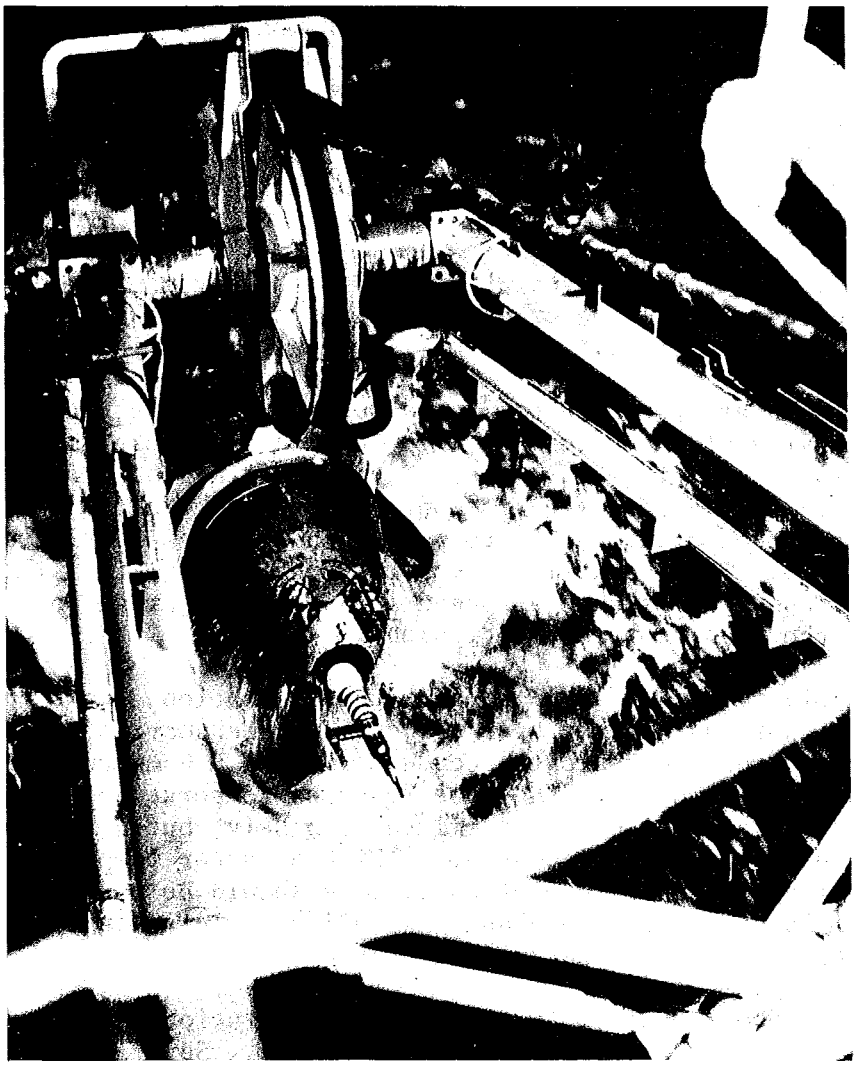
The major effort during the year has been in the development of instrumentation and equipment for a major sea operation scheduled for early 1972. The basis of the measuring system will remain essentially similar to what has been used in the past. A submerged body, towed from a surface ship, carries an array of sensors to measure temperature, velocity and electrical conductivity of the water, and fluctuations of these parameters with high resolution in time and space. Platinum film probes for temperature and velocity have a frequency response extending beyond 1 KHz and at the usual towing speed of about 150 cm per second can resolve features down to 2 or 3 mm in size. Three auxiliary temperature sensors with slower response (up to about 50 Hz) are arranged in a vertical array to obtain information on the mean temperature gradient.

A new conductivity sensor, designed for this operation, looks promising at this time, but has not yet been subjected to exhaustive tests. An array of platinum electrodes measure the conductivity of a 6 mm cube of water and a thermistor just outside the cube measures temperature. Response of the device has not yet been determined precisely, but a spatial resolution of 3 cm or better should be possible. With a faster temperature sensor, salinity determination to a resolution of 1 cm should be possible. Broad band noise level is equivalent to about 4×10^{-4} °/oo in salinity but long term stability has not yet been determined.

The velocity probe is extremely sensitive to vibration generated within the towed body or transmitted down the towing cable. Several isolation devices have been tried in the past with varying degrees of success. A new device has now been designed and although exhaustive tests have not yet been carried out, it appears to offer the best performance yet achieved.

The other major innovation this year has been a digital recording system. Information from the various sensors has previously been recorded on 14 channels of analogue tape of which selected portions have later been digitized for analysis. The new system offers convenience in processing as well as better dynamic range and, using two tape decks, the ability to obtain continuous records with no break for changing tapes.

The forthcoming operations in January-February 1972 will be carried out in the region southwest of Cape Flattery and out as far as Cobb Seamount. There is reason to expect that this experiment will add substantially to our still meager store of knowledge on turbulent mixing in the open ocean. (Nasmyth).



THE TOWED BODY USED IN OCEAN MIXING STUDIES shown during launching at night. The body diameter is 80 cm. Temperature and velocity probes are located side by side at extreme forward end of central spar, and the new conductivity cell can be seen a few centimeters behind and offset to the left. The towing cable with continuous rubber fairing leads to a servo-controlled winch which permits level towing to 300 m, or a repetitive vertical excursion usually 15 m above and below a preset depth.

FROZEN SEA RESEARCH GROUP

E.L. Lewis, Head
J.D. Bradbury
R.A. Lake
A.E. Moody
K. Fujino (visiting scientist, Sapporo, Japan)
S.W. Moorhouse
R.G. Perkin
D.L. Richards
R.B. Sudar
J.A. Sutherland
E.R. Walker

During March and April, 1971 a field operation was conducted from our Greely Fiord base (80° 36' N., 79° 35' W.). Measurements of oceanographic conditions were made along the length of the fiord and, in addition, simultaneously at two locations in the fiord in an attempt to understand water movement and the flushing action of tides. Observations of dye puffs injected immediately below the growing ice sheet showed that the current reversed at a depth of one meter. These studies of circulation in an Arctic fiord system are related to an understanding of pollutant dispersion. In the same context a study of runoff in Arctic regions has been completed in order to estimate the annual fresh water input in the fiord. We consider that we are now able to obtain temperature and salinity measurements at known limits of accuracy during the Arctic winter and spring with the Guildline C.T.D. system. This has incorporated a study of experimental work by the National Research Council on the electrical conductivity of seawater very close to freezing point.

Preliminary experiments were conducted on the freezing point of seawater samples collected immediately below the growing ice sheet in order to ascertain whether there was a significant effect due to the potentially different ionic concentrations of salts in the water at that location.

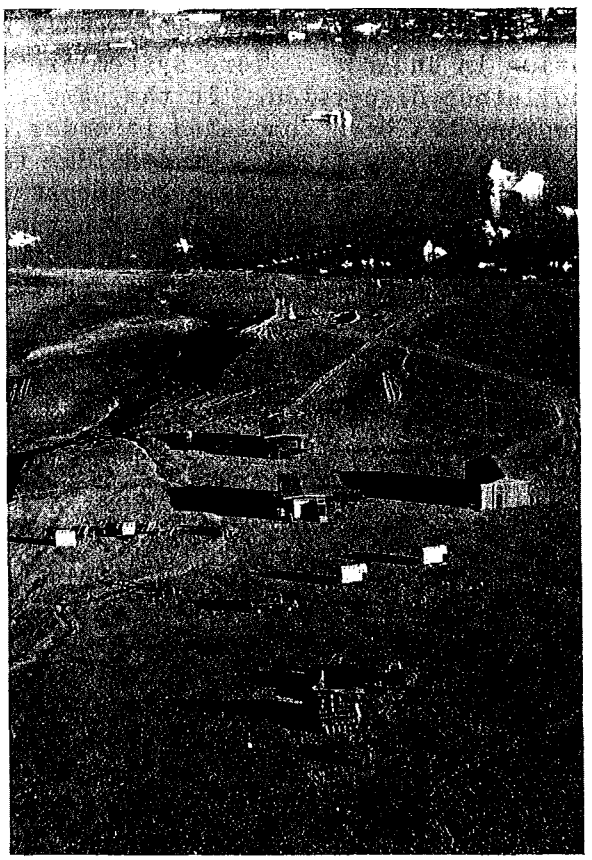
Starting in August, 1971 a series of field operations were undertaken in Cambridge Bay, N.W.T. (105° W., 69° N.). To date two of the four planned operations have been completed. We wish to obtain a complete picture of seasonal variations in surface water structure associated with the growth and decay of sea ice. The precise measurement of salinity and temperature should also enable us to select between a number of models that have been proposed for the vertical mixing associated with salt rejected by sea ice during growth.

A complete oceanographic sled was mounted on a 10,000 pound cedar raft anchored in Cambridge Bay in order to make measurements during the late summer and fall. The raft was frozen into the ice and the sled pulled off it in order to make subsequent measurements through the ice sheet. We have manufactured an under-ice traversing probe to record horizontal variations in temperature and salinity beneath growing sea ice. This instrument will be deployed in Cambridge Bay in February, 1972 in an attempt to discover whether salt rejection processes at the growing interface that have been observed in the laboratory also take place in nature where conditions are not so stable and the depth of water below the sea ice is effectively unlimited. Knowledge of these

processes will aid in understanding the dispersion of any pollutants such as oil that might become mixed in with the ice.

Dr. K. Fujino, visiting scientist from the Institute of Low Temperature Science, Sapporo, Japan, arrived in August 1971 for a two-year stay. He is presently involved in a series of laboratory experiments taking samples of fresh water and seawater across the freezing point. Anomalous behaviour close to freezing is presently receiving intense study.

We are also involved with the Tidal Section in developing an Arctic tide gauge using some of the latest electronic techniques.



Greely Fiord Base (80° 36' N., 79° 35' W.) from the air.

REMOTE SENSING

J.F.R. Gower (under contract)

Most oceanographic work is in a way "remote sensing", but the expression usually refers to 'sensing' such a photography, thermal or microwave radiometry with which scientists study the earth's surface from an aircraft or à satellite.

Today, thanks to recent technological developments, an oceanographer can make an increasing variety of measurements from an aircraft, and so study properties of the ocean that change over time and distance scales that make ship measurements difficult or impossible. In the near future an oceanographer may be able to use a satellite to follow the behaviour of an entire ocean.

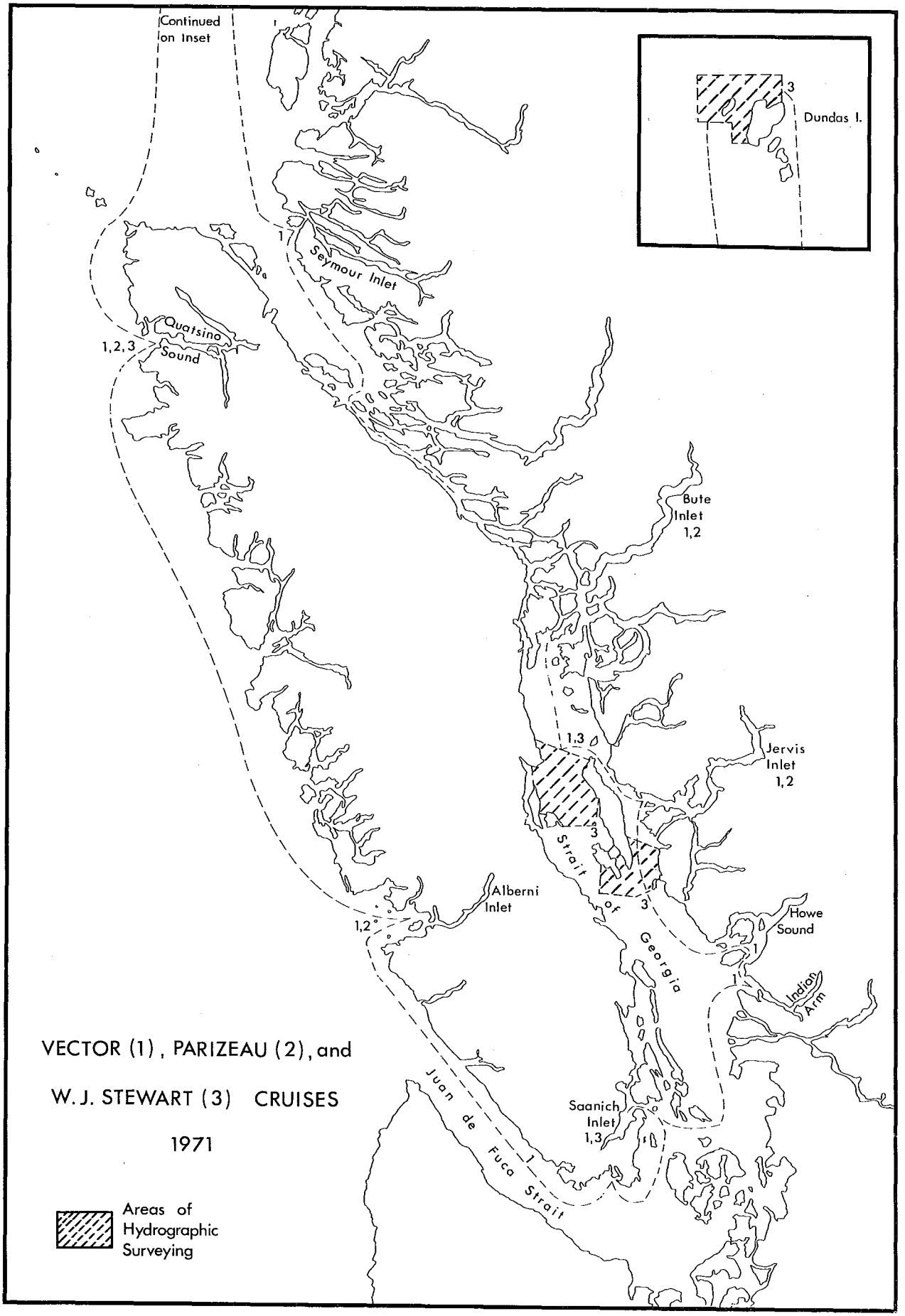
Since September 1971 I have been studying the developments in remote sensing techniques and equipment that may be applicable to oceanography. As well as the large number of papers in this field published each year, the proceedings of the symposia on "remote sensing of the environment" held at the University of Michigan is a useful indication of current capabilities and developments. About 20% of the work discussed at these symposia is relevant to Oceanography. NASA, in conjunction with the US Navy Oceanographic Office, is working on a spacecraft oceanography project and the annual reports on this work show what may be possible using measurements from space. I am preparing a survey of this literature as an internal report in the Marine Sciences Branch.

In 1971 I visited the Bedford Institute of Oceanography, the Institute of Oceanography at UBC, the Canadian Centre for Remote Sensing and Oregon State University for discussions on oceanographic remote sensing.

The most interesting currently operational techniques for oceanographic remote sensing are probably the laser profilometer for measuring wave height, the airborne radiation thermometer and airdroppable instruments for measuring temperature. Other techniques under development include pulsed laser (lidar) measurements of shallow water depth, accurate colourimetry for depth measurement and water body identification and microwave techniques for measuring roughness and possibly currents. An aircraft can also make measurements in the atmosphere near the sea surface.

Negotiations with the Department of National Defence have been underway in Victoria since November 1971 for use of a Tracker aircraft. In an initial program for 1972 I plan to use the aircraft's doppler navigator for investigating surface currents, and to make air turbulence measurements in conjunction with Dr. Miyake at UBC. Later we would want to use either the Tracker or a similar sized aircraft to carry wave height and temperature measuring equipment and an inertial navigation system.

I have also started work on a simple, shore-based, doppler radar to study radar/sea wave reasonance effects. (Gower).


Continued on Inset
Dundas I.
3
Seymour Inlet
1
Quatsino Sound
1,2,3
Bute Inlet
1,2
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Jervis Inlet
1,2
Strait of Georgia
Alberni Inlet
1,2
Howe Sound
Indian Arm
Saanich Inlet
1,3
Juan de Fuca Strait
VECTOR (1), PARIZEAU (2), and
W. J. STEWART (3) CRUISES
1971
Areas of Hydrographic Surveying

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent
F.S. Green - Assistant Marine Superintendent

1971 marked a successful year for Pacific Region ships in the fulfillment of all scheduled requirements. Since this is our first separate annual report the characteristics of each ship is given followed by a resume of activities during 1971.

C.S.S. "PARIZEAU"

Master - A.G. Chamberlain

Chief Engineer - D. Marr

length overall	- 64.3 m (211' 9")	Displacement tonnage	1929.2 tons metric
beam	- 12 m (40' 0")	total complement	- 51 (1898.8 L.T.)
draft	- 4.8 m (16' 0")	capabilities	- tidal & current survey, oceanographic.
shaft hp	- 3400		
speed	- 15 kts		
range	- 12,000 n.m. (22,239 km)	construction	- 1967, Burrard Dry Dock Co., Vancouver, B.C.

Prior to departure to the Western Arctic "Parizeau" served the requirements of P.O.G., M.S.B. (current metering) and M.S.B. (geophysics) and U.B.C. (geology)until June at which time the vessel's configuration was changed from oceanographic to hydrographic. During July-October, "Parizeau" was engaged in Western Arctic hydrography. Shearing of bilge keels and one major shell indent marked the total ice-damage sustained. Following a return to oceanographic configuration the ship completed the year in the service of M.S.B., P.O.G., U.B.C. and U. Vic.

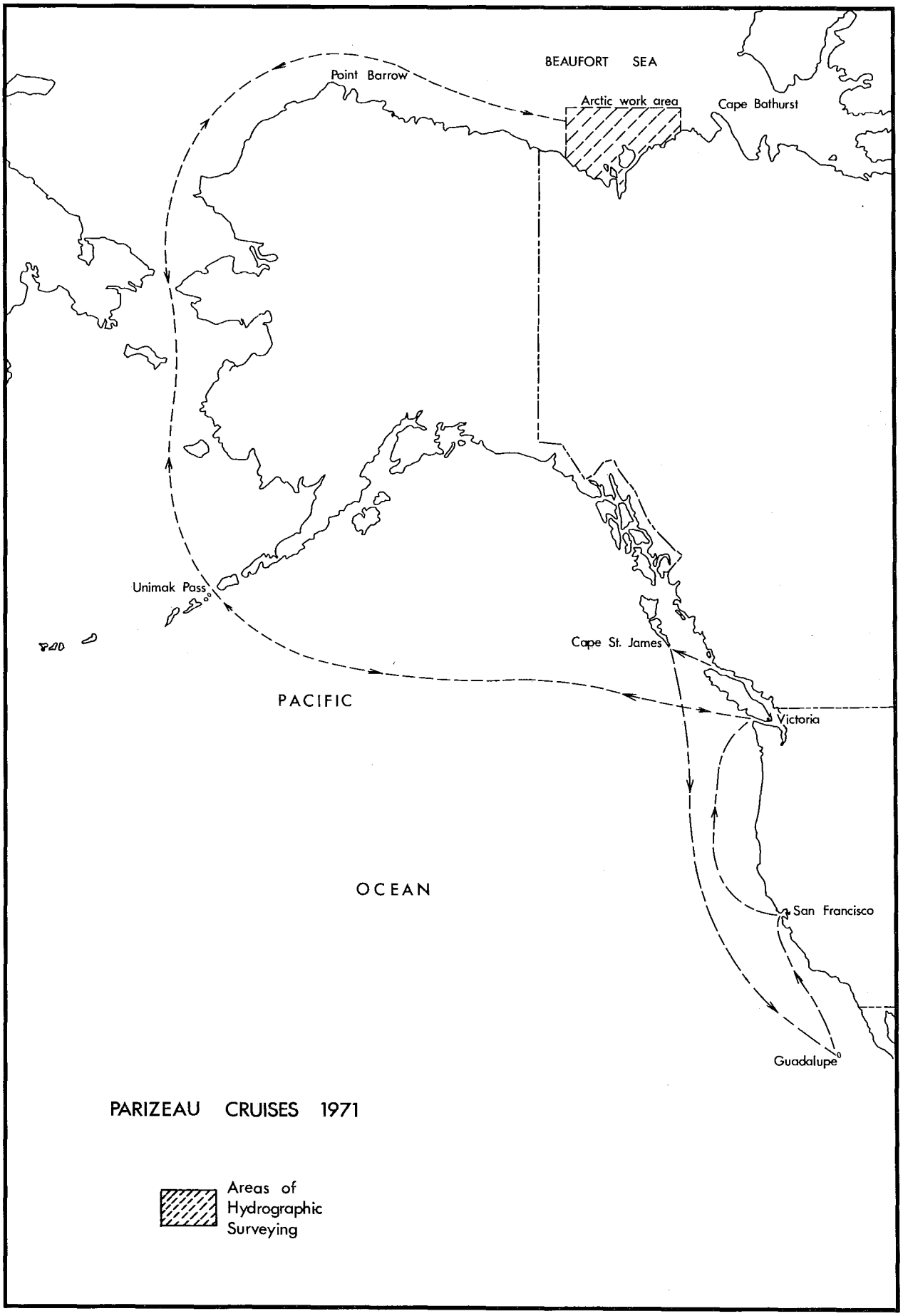
C.S.S. "WM. J. STEWART"

Master - T.P. Scanlan

Chief Engineer - J.D. Henderson

length overall	- 65 m (214')	Displacement tonnage	- 1720.2 tons metric
beam	- 10 m (34')	total complement	- 72 1693.1 L.T.)
draft	- 3.9 m (13')	capabilities	- hydrography
shaft hp	- 1400	construction	- 1932, Collingwood Shipbuilders, Collingwood, Ont.
speed	- 11 kts.		
range	- 4000 n.m. (7,412 km)		

Following annual refit "Wm. J. Stewart" engaged in the annual hydrographer training exercise held this year in Saanich Inlet and adjacent areas during the period February 1 - April 16. From April 17 to October 15 she assumed her normal role in hydrographic surveys of Quatsino Narrows, Strait of Georgia and in the northern area around Dundas and Zayas Islands.


BEAUFORT SEA
Point Barrow
Arctic work area
Cape Bathurst
Unimak Pass
Cape St. James
PACIFIC
Victoria
OCEAN
San Francisco
Guadalupe
PARIZEAU CRUISES 1971
Areas of Hydrographic Surveying

C.S.S. "VECTOR"

Master - C.A. Macaulay

Chief Engineer - G.W. Clouston

length overall	- 39.6 m (130')	displacement tonnage	- 505 tons metric (500.5 L.T.)
beam	- 9.4 m (31')		
draft	- 3.3 m (11')	total complement	- 27
shaft horsepower.	- 700	capabilities	- oceanographic (physical, chemical geology, biological)
speed	- 11 kts		
range	- 3500 n.m.		
		construction	- 1967, Yarrows Victoria, B.C.

Following the annual refit "Vector" served the requirements of MSB, IOUBC and POG mainly in Georgia Strait and the southern inlets. The only incident to marr an uneventful year was a grounding which fortunately caused only bottom paint damage, at the head of Rupert Inlet.

C.S.S. "RICHARDSON"

Master - V.L.E. Dale-Johnson

Chief Engineer - J.N. Henderson

length overall	- 19.8 m (65')	displacement tonnage	- 76.2 tons metric (75 L.T.)
beam	- 4.5 m (15')		
draft	- 2.1 m (7')	total complement	- 7
shaft horsepower	- 360	capabilities	- revisory survey, very limited oceanography
speed	- 10 kts		
range	- 2500 n.m.		
		construction	- 1962, Star Shipyards, New Westminster, B.C.

The requirement of a comprehensive four-year SCI survey and the decision to reassign this small ship to B.C. Coastal revisory survey led to the July 31 - August 25 passage from Tuktoyaktuk, N.W.T., to Victoria, B.C. This voyage was completely ice-free.

C.N.A.V. "LAYMORE"

Master - M. Dyer

Chief Engineer - T. Taylor

length overall	- 53.6 m (176')	displacement tonnage	- 645 tons metric (635 L.T.)
beam	- 9.7 m (32')		
draft	- 3.3 m (11')	total complement	- 33
shaft horsepower	- 1000	capabilities	- oceanography (physical, chemical, geology, biological)
speed	- 10 kts		
range	- 2500 n.m.		
		construction	- 1945, Kewaunee Ship Builders, Kewaunee, Wisconsin, U.S.A.

C.N.A.V. "Laymore" was made available during the 1971/72 fiscal year to the West Coast Working Group through MSB's 75% contribution of all operational costs including a comprehensive refit. During the period January 1 to November 1 this vessel served the scientific users of MSB, DREP, U.Vic., FRB, PEI, and Canadian Forces in coastal waters and offshore.

M.V. "PILOT II"

Master - R.J. Russel Chief Engineer - M. McGuire

length overall	- 21 m (70')	displacement tonnage	- 64 tons metric (63 L.T.)
beam	- 4.5 m (15')		
draft	- .9 m (3')	total complement	- 8
shaft horsepower	- 360	capabilities	- limited hydrography
speed	- 11 kts		
range	- 1500 n.m.	construction	- 1947

Pacific Region commenced hydrographic survey of the McKenzie River system from Hay River, to McKenzie Delta. In support of this assignment M.V. "Pilot II" was chartered during the period June 1 - September 15.

In addition to our activities on MSB vessels, a substantial use was made by MSB staff of the weatherships CCGS "Vancouver" and CCGS "Quadra" and of the CFAV "Endeavour", for deep sea oceanography.

LAUNCHES

With the exception of C.S.L. "Revisor", Pacific Region's twenty hydrographic launches and assorted powered craft performed exceptionally well and an operational efficiency of 98% was recorded. "Revisor" experienced an exceptionally poor performance year and suffered a multitude of mechanical breakdowns. The installation of new propulsion machinery is in progress.

DEPOT

The launch workshop facilities at the Victoria M.S.B. Depot were improved in 1971 and the efforts of the newly acquired shipwright and mechanical staff have contributed largely to the improvement in launch performance and reliability.

TASK FORCES, COMMITTEES AND SIMILAR ACTIVITIES

Stewart, R.W.

Joint Organizing Committee (JOC) of Global Atmoshperic Research Program (GARP) - Vice Chairman.

Canadian Committee for GARP.

Advisory Committee on Oceanic Meteorological Research (ACOMR).

Physical Oceanographic Commission of IAPSO - Chairman.

Scientific Committee on Oceanic Research (SCOR) - Canadian representative.

National Research Council - Advisory Committee on Physics.

IAMAP-IAPSO-SCOR Working Group on Air-Sea Interaction.

Marine Parks - Strait of Georgia Field Task Force.

Pacific Region Directors' Committee.

The Sea Use Council (USA) - Vice Chairman.

International Council of Scientific Unions - COSPAR Committee on Space Research.

The Royal Society of Canada - Selection Committee (interdisciplinary).

Departmental Requirements for Research Facilities - Task Force.

Federal-Provincial Task Force on Strait of Georgia.

Task Force on the Need for a West Coast Institute - Chairman.

Water Management Executive Committee.

English, W.N.

Working Group on Abatement of Pollution from D.O.E. Ships - Chairman.

Oil Spill Task Force Liaison Committee.

Departmental Committee on Conservation of Species and Areas of Natural, Cultural and Historic Interest.

West Coast Working Group (Canadian Committee on Oceanography).

Regional Group - Environmental Problems of the Lower Fraser River and Strait of Georgia.

Marine Parks - Strait of Georgia Field Task Force.

Intergovernmental Oceanographic Commission - Member of Canadian Delegation to Seventh Session.

Science Council Committee on Environmental Problems - Advisor (Essay on State of the Environment in British Columbia).

Comité d'Evaluation - Programme de Maîtrise en Sciences de l'Eau, Université du Québec.

Hydrographic Division

Ages, A.B.
Federal Task Force to Combat Oil Pollution.

Bolton, M.
West Coast Working Group, C.C.O. - Alternate.
Task Force on the Need for a West Coast Institute - Secretary.
National Hydrographic Survey Officers' Appraisal Board.

Sandilands, R.W.
Departmental Working Group on River Estuaries.
Workshop on Offshore Surveys for Mineral Resource Development.

Wigen, S.O.
Hydrographic Committee, Canadian Institute of Surveying.

Wills, R.
Survey Technology Advisory Committee, B.C.I.T.

Ocean Chemistry Division

Wong, C.S.
Advisory Committee - GEOSECS, Carbonate Chemistry Panel.
Advisory Committee - GEOSECS, Panel on standardization of the carbon dioxide system.
Advisory Committee on expanding GEOSECS.

Ocean Physics Division

Bell, W.H.
Federal Task Force on Moran Dam Project.

Garrett, J.F.
Canadian Delegation to Second Meeting of Intergovernmental Working Group on Marine Pollution.
Weathership Oceanography Committee.

Nasmyth, P.W.
IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - Chairman.

Tabata, S.
Intergovernmental Committee on Babine Lake Environmental Problems.
Federal Task Force on Moran Dam Project.
Federal-Provincial Task Force on Squamish Development Project.
Weathership Oceanography Committee.

Thomson, R.E.
Weathership Oceanography Committee.

RESEARCH AND DEVELOPMENT CONTRACTS

1.	Establish Carbon 14 dating laboratory for analysis of oceanographic and other samples - B.C. Research	$37,700
2.	Carry out study of remote sensing applications to hydrography and oceanography - Dr. J.F.R. Gower	$30,000 (2 years)
3.	Inform and demonstrate to Canadian scientists the Japanese approach to problems in Arctic oceanography - Dr. K. Fujino, Hokkaido University	$26,000 (2 years)
4.	Develop selfcontained tide gauge for Arctic use - Institute of Oceanography, University of British Columbia	$12,000
5.	Study temperature and conductivity microstructure in inlets and seas as an aid to understanding turbulent mixing and transport - Institute of Oceanography, University of British Columbia	$20,000 (18 months)
6.	Study interaction of tide, wind and fresh water run-off and their effects on mixing and transport - Institute of Oceanography, University of British Columbia	$16,000 (18 months)
7.	Interpret colour aerial photography of Strait of Georgia to assess feasibility of determining depth contours and high and low water-lines - Airphoto Analysis Associates	$8,000

PATENTS AND LICENSING AGREEMENTS

There were no patents issued or applied for in 1971.

Licensing agreement:

Manufacture of Frozen Sea Arctic Research Units comprising sled, winch, heated enclosure, generator temperature control and waste heat utilization system and engine starting techniques and ice drilling system:

made with (Ocean Components Ltd.
(International Hydrodynamics Ltd.
(National Electrolab Associates Ltd.

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