RESTRICTED

FISHERIES RESEARCH BOARD OF CANADA

AND

MARINE SCIENCES BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

ANNUAL REPORT

OF THE

PACIFIC OCEANOGRAPHIC GROUP

Biological Station
Nanaimo, B. C.

1969

copy 1

December 31, 1969

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Oceanographer in Charge,
Fisheries Research Board of Canada,
Pacific Oceanographic Group,
Biological Station,
Nanaimo, B. C

December 31, 1969

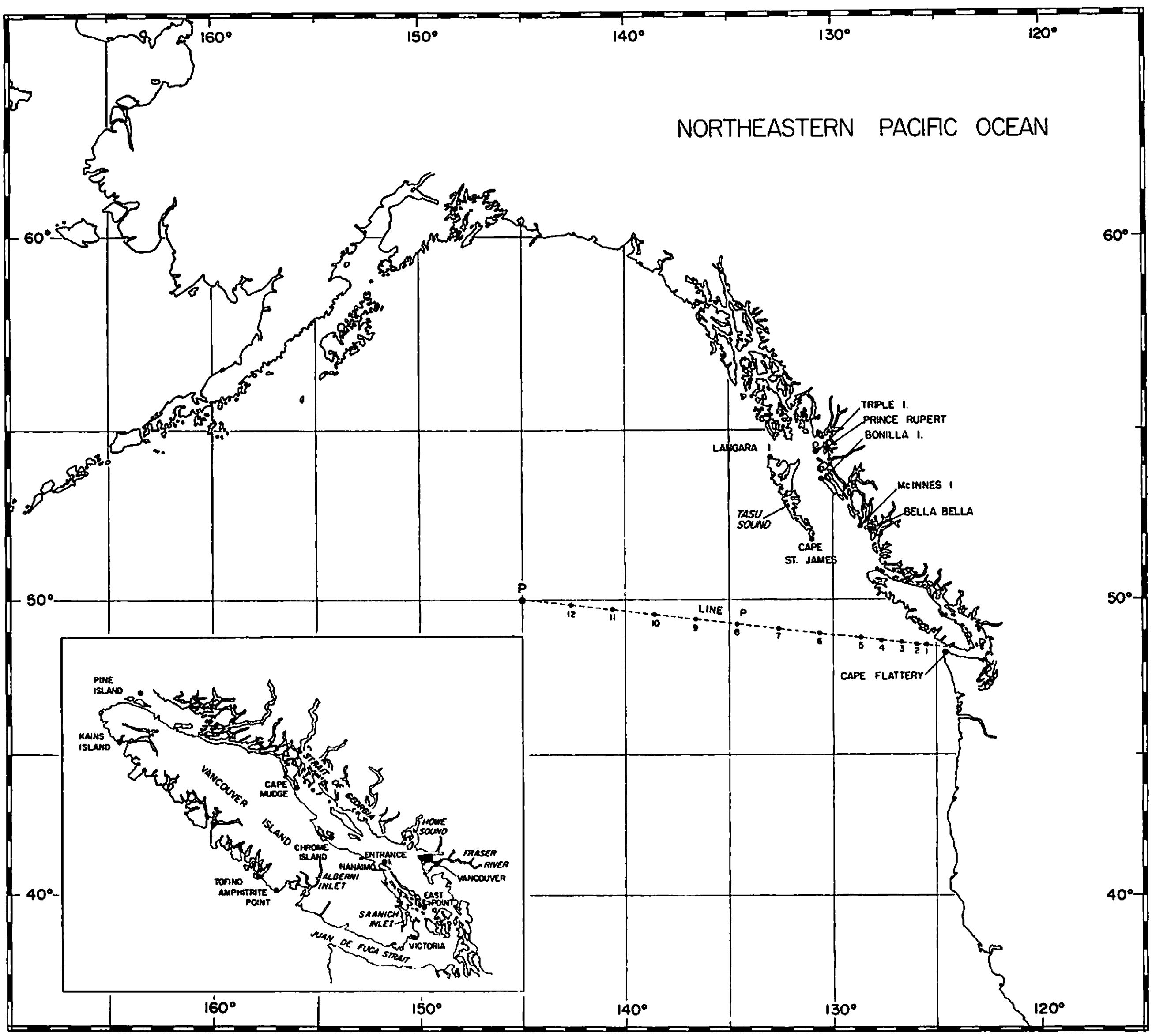

Fig. 1. Area of POG operations in 1969.

FISHERIES RESEARCH BOARD OF CANADA
AND
MARINE SCIENCES BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES
PACIFIC OCEANOGRAPHIC GROUP
BIOLOGICAL STATION, NANAIMO, B. C.

Annual Report 1969

The Pacific Oceanographic Group is a section of the Biological Station, Nanaimo, B.C., and presently consists of employees of the Fisheries Research Board and secondees from the Marine Sciences Branch, Department of Energy, Mines and Resources.

The research programs of the Group include studies (a) in physical and chemical oceanography and (b) on pollution problems, primarily in association with the discharge of pulp mill effluents, sewage and wood solids, into the marine environment. Most of the programs are carried out in cooperation with other government agencies and with universities. Programs in 1969 were essentially a continuation of those carried out in 1968.

Physical oceanographic studies in the Strait of Georgia consisted mainly of continuous current observations from moored buoys, analysis of drift observations for surface circulation in the Fraser River plume area, and completion of a study of a one-dimensional hydrodynamical-numerical model of the Strait of Georgia-Juan de Fuca Strait system.

The results of the analysis of the current velocity data obtained at 200 m depth during the latter part of 1968 indicate that oceanographic events in the Strait of Georgia have time scales from a few hours to several days and, therefore, demonstrate the effectiveness of a relatively long series of observation. The semidiurnal and diurnal components of the tide have by far the greatest influence on the currents in the Strait.

Results of studies of the surface circulation in the vicinity of the Fraser River plume show that, in the absence of significant wind drift, Fraser River water inflowing during the later stages of the ebb or at high-water slack usually maintains its entrant direction until about the next low-water slack, suggesting a basic balance between Coriolis and ebb-tidal forces during the ebb tide. The surface water can subsequently undergo a variety of motions: (a) persistent northward movement (during ebb as well as flood tides) to near the mainland shore west of Howe Sound; (b) flow northward and eastward towards the mainland shore between Burrard Inlet and the South Arm; (c) motion generally westward to the offing of the Canadian Gulf Islands. Fraser River water entering the Strait at low-water slack appears to turn northward immediately. The largest surface speeds occur at or near the mouth of the River during "freshet-and-strong-ebb" conditions. Values from 3 to 5 knots are common. The speeds in the "open" Strait are generally between 1 and 2 knots in the absence of significant winds; they can be greater during strong winds. The smallest value recorded was about 0.2 knots.

A study of a one-dimensional hydrodynamical-numerical model of the Strait of Georgia-Juan de Fuca Strait system has been completed and a report prepared. The model offers considerable insight into the semidiurnal and diurnal tidal phenomena within the system. The values of the depth-mean velocities agree well with such current observations as are available.

Studies of the seasonal and annual variability of the waters extending to about 200 miles off the British Columbia coast were continued. Three cruises were completed in 1969. It appears that, off the west coast of Vancouver Island, the prime factor limiting the depth of surface mixing during late winter and early spring is the salinity of the surface waters. Temperature of the bottom waters overlying the continental shelf off Vancouver Island were everywhere about 1.0 C higher in April 1969 than in September 1967, and October and April 1968.

The Weathership program was expanded to two ships in early 1969. During the May-June patrol of CCGS QUADRA, the collection and analysis of physical oceanographic data were facilitated by the use of a salinity-temperature-depth (STD) system, a STD digitizer and a data acquisition system. Satellite navigation equipment was also successfully operated on this cruise. For the first time, bottom currents were measured for several days using a free-fall current meter system. A buoy program to include current measurements at several depths was begun in cooperation with the Institute of Oceanography, University of British Columbia. A program of studies on air-sea exchange of CO_2 is also being initiated.

Considerable progress in the analyses both of data collected the past year, and of selected data gathered in past years, has been made. The frequency distribution for observed surface temperature and salinity data obtained daily since 1956 at Ocean Station P is trimodal, with a primary mode at 32.60‰, 6.0 C, and secondary modes at 32.80‰, 5.5 C and 32.60‰, 13.0 C. The surface waters had lowest temperature and highest salinity in March, were least saline in October, and had highest temperature in August.

Bottom currents were measured at Ocean Station P using a free-fall current meter system. Preliminary analysis of the velocity records indicates that the mean bottom velocity for the period 29-31 May was 0.015 kt, 073°; for the period 4-7 June was 0.002 kt, 277°.

Comparison of data from Nansen bottle and STD casts has shown that data obtained from a recently laboratory-calibrated STD approximates hydrographic data within the specifications provided by the manufacturer. However, if used over a prolonged time, it is necessary to check the STD calibration at a minimum of two depths for each cast.

Statistical analyses of sea level data for Tofino, Tasu Sound, Prince Rupert and Bella Bella for May 1962 to May 1964 were undertaken. Results show that phase values at most frequencies indicate that the lag between Tasu Sound and Prince Rupert sea-level fluctuations was least and that the lag between Tasu Sound and Tofino sea-level fluctations was greatest.

Daily seawater observations were continued at 17 shore stations. During 1969, the collection of seawater samples for the laboratory analysis of salinity was discontinued at all but one station; instead, measurements of seawater density by hydrometer are being made. This procedure gives an accuracy of 0.5‰ in salinity. Seawater temperatures at most stations were below normal during January, February, August and September. Near-normal temperatures prevailed in spring and early summer until June, when 8 of the stations reported above-normal temperatures. Normal temperature conditions were generally prevalent in October and November, except in Hecate Strait, where above-normal temperatures were observed.

Oceanographic support to the Station's lobster studies was provided in Fatty Basin and adjacent waters, and involved a series of current measurements during May-June. The surface tidal circulation is modified by meteorological conditions in Barkley Sound. Drift cards released on the ebb tide in the channel connecting Fatty Basin and Useless Inlet moved out into Barkley Sound. Some were recovered within the Sound, while others moved out of the Sound and northward toward Amphitrite and Long Beach. Two were picked up on the Washington-Oregon coast. One card, recovered at sea, indicated a drift of about 12 miles per day.

Oceanographic observations from the drill rig SEDCO-135F were continued until May 1969, at which time Shell Oil concluded drilling operations on the continental shelf off the coast of British Columbia.

Oceanographic studies in the waters receiving pulp mill wastes along the east coast of Vancouver Island, and in the northern passages and inlets in existing and potential pulp mill areas, were continued. Data collected during two cruises in 1969 are being processed for publication.

The study of the effect of winds on flushing in Departure Bay is being pursued with collaboration from Dr. T. S. Murty of DEMR, Ottawa. From early numerical analysis, there is agreement of theory and observations on upwelling by strong sustained westerly winds. The effect of offshore winds in such areas may prove to be an important factor in flushing out wastes received at the surface.

Laboratory experiments on pollution by water-borne wood solids were continued. Hydraulically-active diameters of 15 types of wood particles were measured by 3 different methods. Preliminary trials of the sedimentation trough were restricted to wood particles of intermediate to large particle sizes (125-500 microns). The trough was modified to extend its capacity to handle smaller particles and to make more accurate measurements.

A conductivity-temperature-depth system, designed to POG specifications, has been built at the National Research Council in Ottawa. It is designed both for rapid vertical lowerings and for surface towing at high speeds. The instrument has been tested from both a research vessel and a hovercraft. It has performed well at all speeds up to 30 knots.

A. J. Dodimead,
Acting Oceanographer in Charge.

STAFF ACTIVITIES

The 18th Annual Meeting of Pacific Northwest Oceanographers was hosted by the University of British Columbia. Attendees from the Group included Messrs. Wong, DeJong, Abbott-Smith, Miss A. Huyer and Messrs. Collins, Waldichuk, Dodimead and Herlinveaux, the last four giving short contributions on POG's work.

The Second Canadian Oceanographic Symposium was held in Victoria, 16-21 November. Attending from POG for some or all of the sessions were Messrs. Waldichuk, Dodimead, Tabata, Giovando, Herlinveaux, Hollister, Collins, Healey, Abbott-Smith, DeJong and Minkley.

Dr. Waldichuk continued to serve as Chairman of the West Coast Working Group of the Canadian Committee on Oceanography, convening meetings at DREP, Esquimalt, 13 February and at the Biological Station, Nanaimo, 18 September. He attended, on invitation, a meeting of the NASCO-NAECOE Steering Committee on coastal wastes management, Jackson Hole, Wyoming, 7-11 July.

Mr. Dodimead continued to serve as Secretary of the West Coast Working Group of the Canadian Committee on Oceanography, attending meetings on 13 February and 18 September. He attended the Eastern Pacific Oceanic Conference, Lake Arrowhead, California, 15-17 October and scientific meetings of the International North Pacific Fisheries Commission in Vancouver, 19 and 27-29 October.

Dr. Tabata, at the invitation of the Director of the Canada Centre for Inland Waters, visited the Centre and gave a seminar on techniques being employed for current measurements in the Strait of Georgia. He also provided two days of consultations to the staff of the Physical and Limnology Section on subjects related to investigations in lakes and inshore regions of the ocean, 27-30 January. On his return journey he visited the Freshwater Institute, Winnipeg, 31 January. He was in charge of a committee organizing the scientific sessions of the Second Canadian Oceanographic Symposium and presented a paper on current measurements from moored buoys in the Strait of Georgia, 17-20 November.

Mr. Herlinveaux presented a paper on underwater vehicles at a conference on "Man in Cold Water", Montreal, 12-14 May. He was responsible for the administrative arrangements for the 2nd Canadian Oceanographic Symposium and chaired a session on underwater vehicles. He served on an interdepartmental committee on underwater workboats, and attended a meeting of the committee at Bedford Institute, 8 December. He is also a member of a committee on ice drift and oceanographic research in the Arctic Archipelago. He gave lectures on Arctic work to three local groups.

Dr. Collins served on the Advisory Board of the Canadian Oceanographic Data Centre, attending a meeting of the Board in Halifax, 25-26 February.

Dr. C. S Wong attended, on invitation, the GEOSECS planning meeting on the CO_2 system in sea water, Scripps Institution of Oceanography, 31 March-

4 April, serving on committees on total CO_2 measurements and on the development of permanent standards for total CO_2 and alkalinity. He presented two papers at this meeting. He participated, on invitation, in the GEOSECS intercalibration meeting, Scripps Institution, 1-2 October. While there, he conferred with Drs. G. Bien and C. E. ZoBell. He visited Ottawa to confer with Dr. N. J. Campbell and Mr F. G. Barber on proposed chemical programs, and with Mr. J. A. Lowdon to make arrangements for intercalibration of ^{14}C-dating techniques, 4 November. He visited Dr. Max Blumer, Woods Hole Oceanographic Institution to discuss oil pollution research 7 November and conferred at Bedford Institute with Messrs. A. R. Coote and I. W. Duedall regarding the Hudson-70 chemical programs, 8-11 November.

Messrs D. Healey and C. DeJong participated in a cruise for the intercalibration of continuous-recording salinity-temperature-depth (pressure) instruments aboard CSS DAWSON, 4-12 September.

VISITORS

During February, visitors included: Dr. T. M. Dauphinee, National Research Council, Ottawa; Dr. G. Mackie, Department of Zoology, University of Victoria; Mr. D. Wallen, Simon Fraser University and Professor T. Tabata, Hokkaido University, Japan.

Visitors during March and April included Dr. C. P. Mann and Messrs. D. Wells, R. Reiniger and A. Bennett of the Bedford Institute, Dartmouth, N.S.; Professor J. Raymont, Chairman, Department of Oceanography, University of Southampton; Messrs. D. M. Francis and D. Robertson, Canada Centre for Inland Waters, Burlington.

During May and June visitors were: Mr. F. G. Barber, Marine Sciences Branch, Ottawa; Mr. L. Draper, National Institute of Oceanography; Mr. G. L. Holland, Marine Sciences Branch, Ottawa; Mr. E. Kaye, Royal Australian Navy Research Laboratory, Sidney, Australia; Mr. E Jerome, Institute of Oceanography, University of British Columbia; Mr. A. H. Roberts, Capital Regional Planning Board, Victoria; Mr. Tony Young, Department of Chemistry, University of Washington.

Visitors during July and August included: Professor N. Heaps, Tidal Institute, Liverpool; Dr. C. Maunsell, Atlantic Oceanographic Laboratory, Bedford Institute; Mr. H. E. Sweers, Canadian Oceanographic Data Centre, Ottawa; Dr. H. Maeda, Shimonoseki University of Fisheries, Japan; Dr. T. Sano, Tokyo University of Fisheries, Japan; Mr. D. E Amstutz, Department of Oceanography, Oregon State University.

During September and October visitors were: Mr. K. D. Waldron, Bureau of Commercial Fisheries, Seattle; Dr. J. R. Longard, Defence Research Establishment Atlantic, Dartmouth, N.S.; Mr. H. M. Kelly, Ministry of Defence, United Kingdom; Captain R. W. Haupt, U.S. Navy, Office of the Oceanographer of the Navy, Washington, D.C.; Mr. A. W. Magnitsky, Office of Naval Operations, Washington, D.C.; Mr. J. F. Ropek, United States Naval Ordnance Systems Command; Commander R. Whitmore, Hydrographer, Royal Australian Navy; Dr. O. M. Johannessen, McGill University and Mr. J. Ganton, Defence Research Establishment Pacific.

Visitors during November and December included: Messrs. M. M. Kleinerman and L. Schroeder, United States Naval Ordnance Laboratory, Silver Spring, Maryland; Dr. H. S. Weiler, Canada Centre for Inland Waters, Burlington, Ont.; Mr. K. Yuen, Marine Sciences Branch, Ottawa; Dr. H. Grant and Captain B. Marsh, Defence Research Establishment Pacific, Esquimalt; Mr. J Brown, CBA Engineering Ltd.; Mr. M. McCreery, Lockheed Aircraft Corp.; Mr. L. L. Gentry, Lockheed Offshore Petroleum; Messrs. F. Busby, M. Costin, and Commander J. Finland, U.S. Navy Oceanographic Office and Dr. L. Druehl, Simon Fraser University.

Other visitors during the year included: Mr. K. Crocker, Naval Underwater Warfare Center East; Dr. C. N K. Mooers, Oregon State University,

Dr. G. Needler, Bedford Institute; Miss L. Boilard and Miss A. Huyer, Marine Sciences Branch, Ottawa; Mr. L. Landerer, Swedish Water and Air Pollution Research Laboratory; Mr. E. J. Perkins, University of Strathclyde, Marine Laboratory, Scotland; Messrs. J. Garrett and R. Johns, Institute of Oceanography, University of British Columbia.

TABLE I. SEA AND FIELD OPERATIONS 1969

Physical Oceanography - Strait of Georgia

Cruise number	Dates	Vessel	Type of observations	Senior scientist	Scientific party
HC-1-69	8 Jan.	SRN HOVERCRAFT 021	Temperature, salinity	S. Tabata	5
		PARIZEAU	Temperature, salinity, dissolved oxygen	P. Crean	8**
MC-1-69	16 Apr	PARIZEAU	Buoy mooring of current meters	S. Tabata	6*
MC-1A-69	18 Apr	INVESTIGATOR	Recovery of buoy-moored current meters	L.F. Giovando	2*
MC-1B-69	22-23 Apr	PARIZEAU	Recovery of buoy-moored current meters	S. Tabata	6*
69-1	6 May	LAYMORE	Temperature, salinity, dissolved oxygen	S. Tabata	4
MC-2-69	15 May	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
69-2	20-28 May	LAYMORE	Current, drift drogues, temperature, salinity	S. Tabata	3
MC-3-69	18 Jun	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
MC-4-69	10 Jul	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*

TABLE I (CONT'D)

Physical Oceanography - Strait of Georgia (cont'd)

Cruise number	Dates	Vessel	Type of observations	Senior scientist	Scientific party
69-3	7-11 Jul	LAYMORE HYDRO LAUNCHES	Current, drift drogues	S. Tabata A. Ages	7**
69-3	7-11 Jul	A.P. KNIGHT	Current, temperature, salinity	J. Wong	3**
HC-2-69	26-27 Jul	SRN HOVERCRAFT 021	Towed STD trials	S. Tabata	4
MC-4A-69	27 Jul	PARIZEAU	Recovery of buoy-moored current meters	S. Tabata	6*
MC-5-69	28 Aug	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
MC-6-69	18 Sep	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
MC-7-69	16 Oct	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
MC-8-69	25 Nov	PARIZEAU	Servicing of buoy-moored current meters	S. Tabata	6*
Various	Twelve 1-day trips between 1 May-1 Dec	VARIOUS	Checking of buoy-moored current meters	Various	2

* Carried out with the assistance of the Canadian Hydrographic Service.

** Cooperative survey between POG and the Tidal and Current Surveys Division of the Canadian Hydrographic Service.

TABLE I (CONT'D)

Physical Oceanography - Oceanic-Coastal

Cruise number	Dates	Vessel	Type of observations	Senior scientist	Scientific party
	5-11 Mar	G.B. REED	Temperature, salinity, oxygen, nutrients, plankton tows and hauls	R.H. Bigham	6
	17-18 Mar	PARIZEAU	Mooring of buoy and current meter	S. Huggett (MSB, Victoria) (R.H. Bigham)	6
OC-69-1	14 Apr-1 May	LAYMORE	Temperature, salinity, nutrients, plankton tows	A.J. Dodimead	5
OC-69-2	29 Sep-17 Oct	ENDEAVOUR	Temperature, salinity, nutrients, plankton tows	C.A. Collins (29 Sep-9 Oct) D.A. Healey (9-17 Oct)	4

Physical Oceanography - Support

Cruise number	Dates	Vessel	Type of observations	Senior scientist	Scientific party
	15-27 Jan	ENDEAVOUR	DREP Fluid Dynamics	H. Grant, DREP (R.H. Bigham)	8
	29 Jan-7 Feb	ENDEAVOUR	DREP Fluid Dynamics	H. Grant, DREP (J.A. Stickland)	
	30 Mar-3 Apr	ST. ANTHONY	Expendable B.T. observations	R.H. Bigham	2
	30 Jun-24 Jul	ENDEAVOUR	Temperature, salinity	H. Grant, DREP (R.H. Bigham)	14

TABLE I (CONT'D)

Physical Oceanography - SEDCO 135F Drilling Rig

Dates	Vessel	Type of observations	Senior Scientist	Scientific party
9-10 Jan	DRILL RIG	Currents	R.H. Herlinveaux	1
12-13 Feb	DRILL RIG	Currents	R.H. Herlinveaux	1
6-21 Mar	DRILL RIG	Currents	R.H. Herlinveaux	1
14-16 Apr	DRILL RIG	Currents	R.H. Herlinveaux	1
		Physical Oceanography - Fatty Basin		
1-2 May	SMALL BOATS	Currents temperature, salinity, drift drogues, turbidity	R.H. Herlinveaux	2
6-7 May	SMALL BOATS		R.H. Herlinveaux	2
22-23 May	SMALL BOATS		R.H. Herlinveaux	2
29-30 May	SMALL BOATS		R.H. Herlinveaux	2
5-6 June	SMALL BOATS		R.H. Herlinveaux	2
12-13 June	SMALL BOATS		R.H. Herlinveaux	2
19-20 June	SMALL BOATS		R.H. Herlinveaux	2
3-4 July	SMALL BOATS		R.H. Herlinveaux	2
7-9 July	SMALL BOATS		R.H. Herlinveaux	2
		Physical Oceanography - Bowie Seamount		
11-16 Aug	PARIZEAU	Temperature, salinity, currents, biological observations	R.H. Herlinveaux	3
25-29 Nov	PARIZEAU	Retrieval of current meter	R.H. Herlinveaux	1

TABLE I (CONT'D)

Ocean Station P - Line P

Cruise number	Dates	Ship	Scientific party
P-69-1	10 Jan-27 Feb	CCGS VANCOUVER	O. Joergensen
P-69-2	21 Feb-10 Apr	CCGS QUADRA	D.A. Healey, R.L.K. Tripe
P-69-3	4-Apr-22 May	CCGS VANCOUVER	J. Wong
P-69-4	16 May-3 July	CCGS QUADRA	C.A. Collins, C. DeJong, J. Huyer, L. Boilard
P-69-5	27 Jun-14 Aug	CCGS VANCOUVER	B. Minkley
P-69-6	8 Aug-25 Sept	CCGS QUADRA	R.L.K. Tripe, C. Cruchy, M. Anctil, R.W. Drinnan
P-69-7	19 Sept-6 Nov	CCGS VANCOUVER	K.A. Gantzer
P-69-8	31 Oct-11 Dec	CCGS QUADRA	Master and Ship's Crew
P-69-9	5 Dec-15 Jan	CCGS VANCOUVER	B. Minkley

TABLE I (CONT'D)

Pollution

Dates	Vessel	Project observations	Senior scientist	Scientific party
May 31-June 4	MARY M	Port Alice Bacteriological survey	A.E. Werner	2
June 10-June 11	A.P. KNIGHT	Outer Burrard Inlet Oceanographic stations Bacteriological sampling	J.H. Meikle	2
June 12-June 13	A.P. KNIGHT	Departure Bay Oceanographic stations	J.H. Meikle	2
Aug 4-Aug 13	LAYMORE	E. coast Vancouver I., Baynes Sound, Northumberland Channel, Stuart Channel, Haro St., Juan de Fuca Strait. Oceanographic stations.	J.H. Meikle	4
Sept 15-Sept 25	LAYMORE	Fisher Channel, Cousins Inlet, Douglas Channel, Kitimat Arm, Prince Rupert Harbour, Morse Basin, Wainwright Basin, Porpoise Harbour. Oceanographic stations.	J.H. Meikle	4
Oct. 29	VICTORIA VI (Tugboat)	Alberni Harbour Bacteriological sampling.	A.E. Werner	2

Notes: 1. Bacteriological sampling in Burrard Inlet was carried out to obtain coliform counts.

2. Bacteriological sampling in Port Alice was carried out to obtain cellulo-clastic micro-organisms; in Alberni Harbour to obtain ligno-clastic micro-organisms.

3. Oceanographic surveys included bathythermograph, secchi disc and serial observations of salinity, temperature, dissolved oxygen, pH and alkalinity.

TABLE II. COOPERATION AND LIAISON

Defence Research Establishment Pacific, Esquimalt: provides a working liaison with the Canadian Forces. Engineering consultation and ships' equipment are provided along with close coordination of ship requirements. It receives oceanographic support for sea operations and oceanographic data for defence research.

Marine Sciences Branch, Department of Energy, Mines and Resources, Victoria: has operated CSS PARIZEAU and CSS VECTOR in the West Coast ships' pool. The tidal surveys staff of the Canadian Hydrographic Service cooperated in studies of the Strait of Georgia and of the continental shelf waters by providing support to the moored current meter programs.

Canadian Forces (Royal Canadian Navy): has provided and operated the research vessels CNAV ENDEAVOUR and CNAV LAYMORE. All Canadian bathythermographs used in the Pacific are calibrated and repaired at the RCN facility, HMC Dockyard, Esquimalt.

Marine Services (Department of Transport): provides facilities for daily seawater observations at 17 lightstations. Bathythermograph observations are made by DOT personnel from CCGS VANCOUVER and CCGS QUADRA. Accommodation and assistance for oceanographers on these ships have been provided. A DOT helicopter has been used for transportation to lighthouses on missions connected with daily seawater observations and a hovercraft has been provided for testing of high-speed towed equipment.

Air Services (Department of Transport), Toronto, Vancouver and Victoria: provides meteorological data and special analyses, and gives professional consultation on studies of ocean heat budgets and other problems involving air-sea interaction. Pacific Oceanographic Group operates a pyranometer at Departure Bay, as part of the radiation network of the DOT Air Services on the Pacific Coast.

Maritime Forces Weather Centre: operates the Oceanographic Service for Defence (Oceanographic Information Service) which collects, analyzes, collates and distributes temperature data from ships and aircraft. Pacific Oceanographic Group provides research and scientific support to the Service.

United States Weather Bureau, Washington, D.C.: provides extended weather forecasts for the northern Pacific area and weather summeries on request. The Extended Weather Forecast Division provides cards with mean monthly sea-level atmospheric pressures, which have been used directly in our computer for evaluating transports.

U.S. Fleet Numerical Weather Facility, Monterey, California: provides print-outs and charts of monthly mean radiation data and potential mixed-layer depths.

Fisheries Service, Vancouver: Continues to observe daily water temperatures in the Fraser River, at New Westminster. Close cooperation is maintained on marine pollution problems.

Health Branch, B.C. Department of Health Services and Hospital Insurance, Victoria and Vancouver: participates in cooperative studies of marine pollution and provides bacteriological analyses of water samples.

Canadian Oceanographic Data Centre, Ottawa (Marine Sciences Branch, Department of Energy, Mines and Resources): machine processes and publishes the oceanographic data. Advises on the most suitable means of programming data for machine computations and tabulation.

Canadian Oceanographic Identification Centre, Ottawa: sorts and identifies zooplankton samples.

Canadian Government Printing Bureau, Esquimalt Unit: provides exceptional service in printing data records and manuscript reports, and in other printing services.

Directorate of Scientific Information Service, Ottawa: provides library, indexing and abstracting services.

Scripps Institution of Oceanography, La Jolla, California: surface seawater samples, at the beginning of each weathership patrol, and 3-weekly composite samples of rain water are taken by weathership personnel at Ocean Station P, for tritium analysis by SIO.

Health and Safety Laboratory, New York (U.S. Atomic Energy Commission): receives 2 ion exchange columns through which rain has passed, on each weathership patrol, for fallout radioactivity studies.

University of Washington, Department of Chemistry, Seattle, Washington: samples are taken at various depths and processed by weathership personnel on board the CCGS VANCOUVER for carbon-14 analysis by Dr. A.W. Fairhall at this University.

Institute of Oceanography, University of British Columbia: besides the informal contacts with staff and students of IOUBC, a joint MSB-IOUBC project has been initiated at Ocean Station P.

STAFF LIST

Fisheries Research Board

M. Waldichuk, Ph.D. (seconded to Headquarters Staff, 1 August 1969)	Scientist 5	Oceanographer-in-Charge (Pollution)
A.J. Dodimead, M.Sc.	Scientist 3	Acting Oceanographer-in-Charge Physical Oceanography (N. Pacific, Coastal)
L.F. Giovando, Ph.D.	Scientist 3	Physical Oceanography (Strait of Georgia)
S. Tabata, Ph.D.	Scientist 3	Physical Oceanography (Strait of Georgia, NE Pacific)
P.B. Crean, M.A.Sc. (on educational leave from 1 August 1969)	Scientist 2	Physical Oceanography (Strait of Georgia)
R.H. Herlinveaux	Technician (EG9)	Physical Oceanography (Burke Channel, Barkley Sound, Arctic).
H.J. Hollister	Technician (EG9)	Daily Seawater Observations, Data Processing, Records.
A.E. Werner	Technician (EG9)	Pollution (Chemical)
J.A. Stickland	Technician (EG7)	Strait of Georgia
J.H. Meikle	Technician (EG6)	Pollution
K.A. Gantzer	Technician (EG5)	Ocean Station P
J. Wong, B.Sc. (to 30 October 1969)	Technician (EG5)	Ocean Station P, Strait of Georgia
R.H. Bigham	Technician (EG5)	N. Pacific, Coastal
O.H. Joergensen, B.Sc. (to 31 July 1969)	Technician (EG4)	Ocean Station P
R.E.O. Forbes	Technician (GL9)	Oceanographic Stores, Equipment Maintenance and Calibration
S.B. Bowers (Mrs) (to 15 October 1969)	Stenographer 5	Administrative Secretary
Nadon, V.M. (Term Employee - to 30 September 1969)	Clerk 2	Draughting
D.A. Blank (Term Employee - to 30 September 1969)		Pollution
B.R. deLange Boom (Seasonal Employee - 2 May-2 September 1969)	Student Assistant	Physical Oceanography
T.E. Bohart (Seasonal Employee - 30 June-29 August 1969)	Student Assistant	Physical Oceanography

STAFF LIST (CONT'D)

L. Spearing (Seasonal Employee - 20 June-29 August 1969)	Student Assistant	Physical Oceanography
T. Touminen (Miss) (Seasonal Employee - 1 May-29 August 1969)	Student Assistant	Physical Oceanography

Marine Sciences Branch

C.A. Collins, Ph.D.	Research Scientist 1	Physical Oceanography (Ocean Station P)
C.S. Wong, Ph.D.	Research Scientist 1	Chemical Oceanography (Ocean Station P)
D.A. Healey, M.Sc.	Scientific Officer 2	Physical Oceanography (Ocean Station P)
K.B. Abbott-Smith	Technician (EG3)	Ocean Station P Data
C. DeJong	Technician (EG4)	Ocean Station P
B.G. Minkley	Technician (EG4)	Ocean Station P
R.L.K. Tripe (to 30 October 1969)	Technician (EG4)	Ocean Station P
R. Bellegay (from 1 April 1969)	Technician (EG4)	Ocean Station P
A. Huyer (Miss) (5 January-25 September 1969)	Scientific Officer 2	Ocean Station P
L. Boilard (Miss) (12 May-4 July 1969)	Scientific Officer 2	Ocean Station P

PUBLICATIONS AND REPORTS

Scientific Journals

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No. 10. Ocean Weather Station 'P', North Pacific Ocean, February 23 to May 23, 1968. 149 pp.

INVESTIGATOR'S SUMMARIES

1. STRAIT OF GEORGIA - PHYSICAL OCEANOGRAPHY

S. Tabata, P. B. Crean, L. F. Giovando, and J. A. Stickland

(a) Current velocity measurements from moored buoys - S. Tabata and J.A. Stickland and S. Huggett (MSB, Victoria)

The current-velocity measurements from moored buoys in the Strait of Georgia constitute the main field program of physical oceanography for the area. The program is carried out in conjunction with that of the Tidal and Current Surveys Division of the Canadian Hydrographic Service who are making similar observations in the same general area with emphasis, however, on tidal information.

The main purpose of the present program is to examine the current velocities in one area of the Strait for much longer duration than has hitherto been done so that accurate knowledge on the non-tidal current velocities can be obtained. In order to achieve this, a line of 3 stations, spaced 10 km apart, between Valdes Island and Iona Jetty has been established, and current velocities are measured continuously at depths of 4, 50 and 200 m depth from each of the 3 stations (Fig. 2). The observations commenced in mid-April 1969 (mooring from one station was snagged by some unknown vessel soon after mooring was established. This station was re-established in mid-July). It is planned to continue the present series of observations for one year from each of the stations. Observations at 4 m depth were discontinued due to difficulties in making reliable measurements at this depth. Survey details are summarized in Table III.

The Aanderaa recording current meters are capable of making temperature measurements as well as current velocities. To date their performances have been very good, and current velocity and temperature data have been recorded at 10-minute intervals successfully for up to one-half of the year. The percentage data retrieval is 94%. Only a few minor difficulties were noted. The Plessey recording current meters placed at 4 m depth have not produced satisfactory data as yet.

The data obtained from the Aanderaa current meters are stored on 1/4 inch magnetic tapes. They are sent to Bergen, Norway, for initial translation. Computer programs are being written to further process the data so that they will be in analyzable form.

The buoys, moorings and instruments are serviced at approximately monthly intervals. CGS PARIZEAU is used for this task. Weekly inspection of buoys and surface moorings are made, availability of vessels permitting.

(b) Preliminary examination of current velocities measured at 200 m depth from moored buoys during 1968 - S. Tabata

During the latter part of 1968 current velocity measurements were made at two locations, one at Station F-11 (Lat. 49°03.12'N, Long. 123°25.88'W,

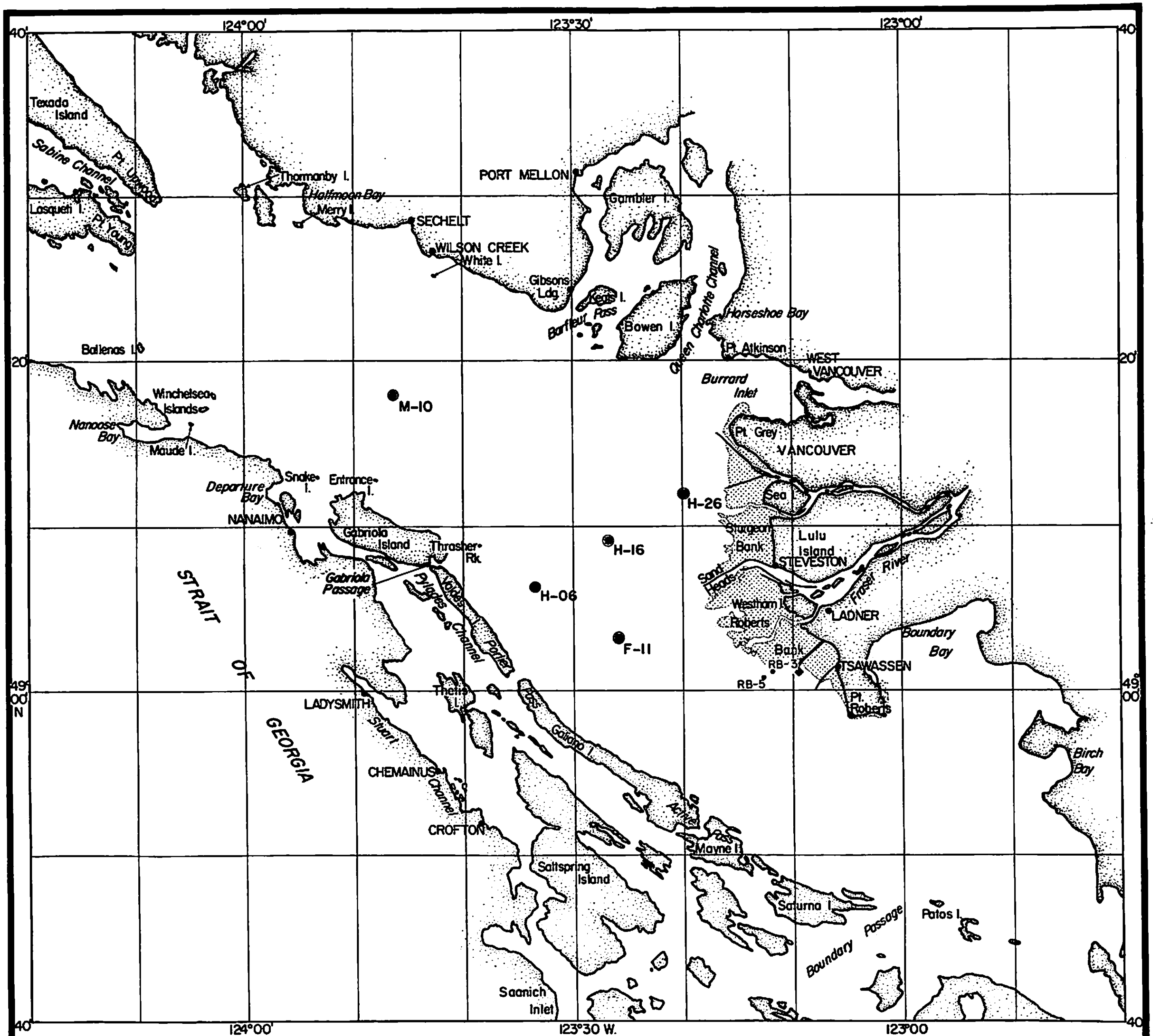


Fig. 2. Chart showing location of stations occupied during 1969. The large circles denote moored current meter stations.

TABLE III. SUMMARY OF CURRENT MEASUREMENTS.

Station number	Latitude (N)	Longitude (W)	Depth (m)	Instrument	depth (m)	Dates	Remarks
H-06	49°06.22'	123°33.74'	250	Plessey*	4	+16-27 Apr.	*Fins damaged, as discovered on Apr. 18. +Buoy mooring presumably cut by tow line; surface float found drifting on Apr. 17; recovered on Apr. 18.
						++17-28 Jul.	++Fins again noted to be damaged.
				Aanderaa	50	+++16-21 Apr. 10 Jul. -	+++Subsurface buoy in position until Apr. 21 when it was retrieved. Surface float: <u>Geodyne</u> toroidal type.
				Aanderaa	200	+++16-21 Apr. 10 Jul. -	
H-16	49°09.04'	123°19.80'	290	Aanderaa	50	16 Apr. -	Surface float:- D.O.T. river navigational buoy - on loan from Dept. of Transport.
				Aanderaa	200	16 Apr. -	
H-26	49°11.93'	123°19.80'	170	Plessey*	4	16-24 Apr.	*Fins damaged, and leakage noted on Apr. 23.
				Aanderaa	50	+16 Apr. - 24 Jul. 28 Aug. -	+Surface buoy reported adrift on Jul. 25, whole buoy assembly dragged 5 miles to north. Examination of data showed accident occurred at about 2045 (PST) Jul. 24.
				Aanderaa	140	+16 Apr. - 24 Jul. 28 Aug. -	Surface float:- <u>Geodyne</u> toroidal type.

Depth 300 m) between Porlier Pass and Sand Heads and another at Station M-10 (Lat. 49°17.32'N, Long. 123°44.46'W, Depth 295 m) between Entrance Island and Halibut Bank. The measurements were made, in part, to examine the current velocities at depths relatively free from surface disturbances and, in part, to obtain information upon the performance of two types of magnetic tape recording current meters, two Geodyne and two Plessey, that were recently acquired. The Geodyne meters were placed at 200 m and the Plessey at 50 m depth.

One Geodyne meter recorded successfully for 49 days at 15 minute intervals in "burst sampling" of 15 samples every 5 seconds for 75 seconds. The other sampled for 40 days, after which it became inoperative due to battery corrosion.

One Plessey meter recorded data for 26 days but due to a fault in the instrument the information is difficult to examine systematically. The other did not yield any useful information.

At Station F-11 where the measurement commenced in mid-August, a considerable down-Strait flow (ebb) was noted at 200 m depth, the rate being approximately 3 km/day (Fig. 3A). The energy of the currents associated with the semi-diurnal component was more than 3 times that of the diurnal component. At Station M-10 where the measurement commenced in mid-October a more variable net flow was indicated (Fig. 3B). During the first week, a down-Strait flow of 6 km/day occurred; this was followed by 3 weeks of up-Strait flow of 2 km/day. Then followed one week when no net flow occurred (just the reversing tidal flow being present). During the last week of observations an up-Strait flow of 2 km/day occurred again. Here the energy of the current associated with the semi-diurnal component was again more than 4 times that associated with the diurnal component. A comparison of spectral energies in the major tidal frequencies indicates that Station F-11 contained a peak at the inertial frequency, while M-10 did not. Significant peaks occurred at both stations at periods of about 8, 6, 5 and 4 hours. Spectral energy densities for both stations decreased at the rate in the range of - 5/3 or - 4/3 power in the frequency range between 1/10 and 1.0 cycles per hour, suggesting a cascading of "turbulent" energy toward higher frequencies (Fig. 4).

The results from these 2 stations indicate that oceanographic events having time scales from four hours to several days are present and therefore demonstrate the effectiveness of a relatively long series of observation.

(c) Short term current velocity profile measurements - S. Tabata, L.F Giovando, J. Wong.

Two short cruises were made in the Strait of Georgia to make current velocity profile measurements.

The first series of measurements were made at Station H-16 (one of the 3 stations from which continuous measurements of current velocity at two depths are made) from CNAV LAYMORE in May. The data obtained will complement those taken from moored instruments. Observations were made at hourly intervals for 4 days from a lifeboat provided by the ship and moored to an anchored surface buoy.

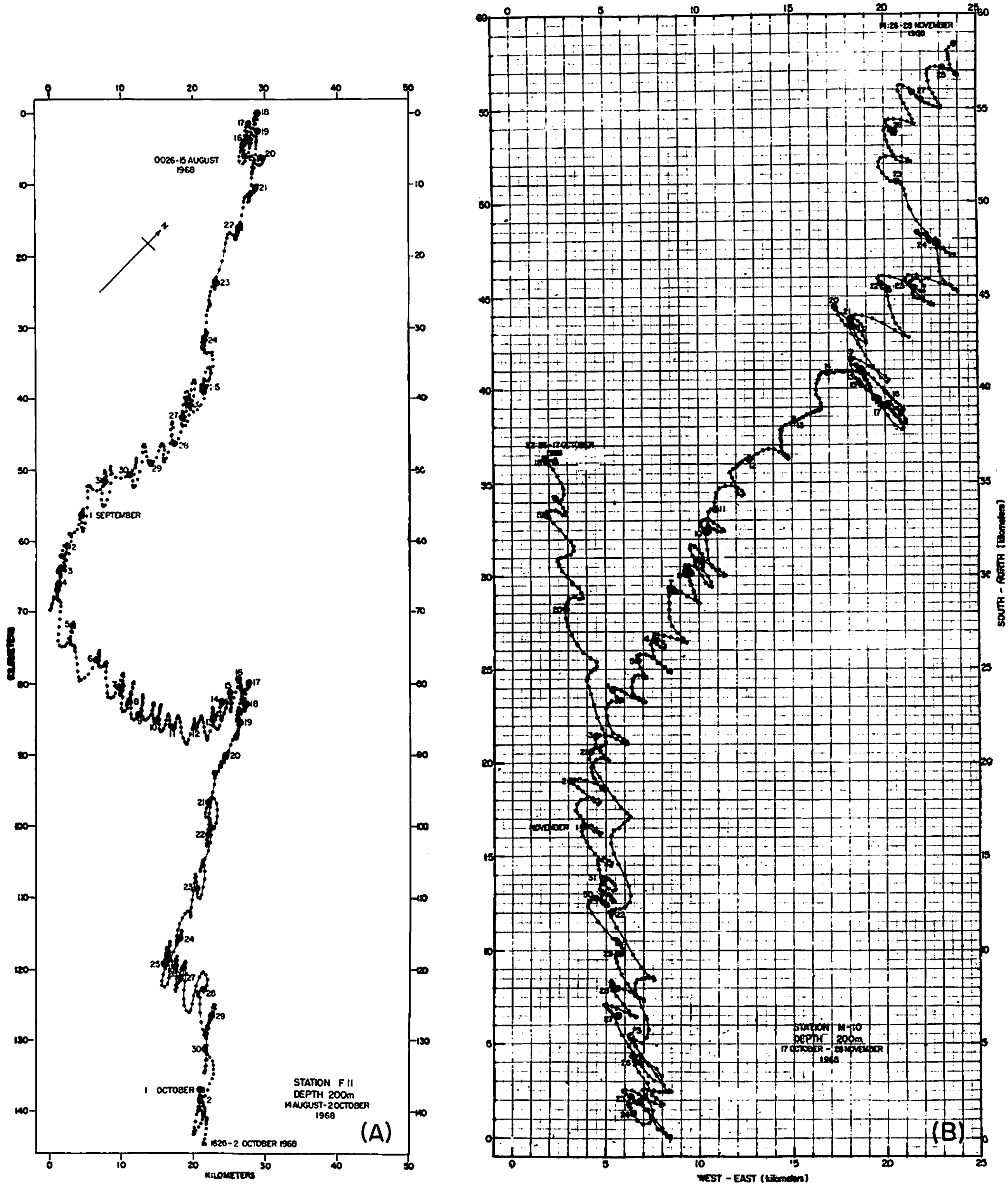


Fig. 3. Progressive vector diagram showing net motion at 200 m depth for (A) Station F-11 and (B) Station M-10.

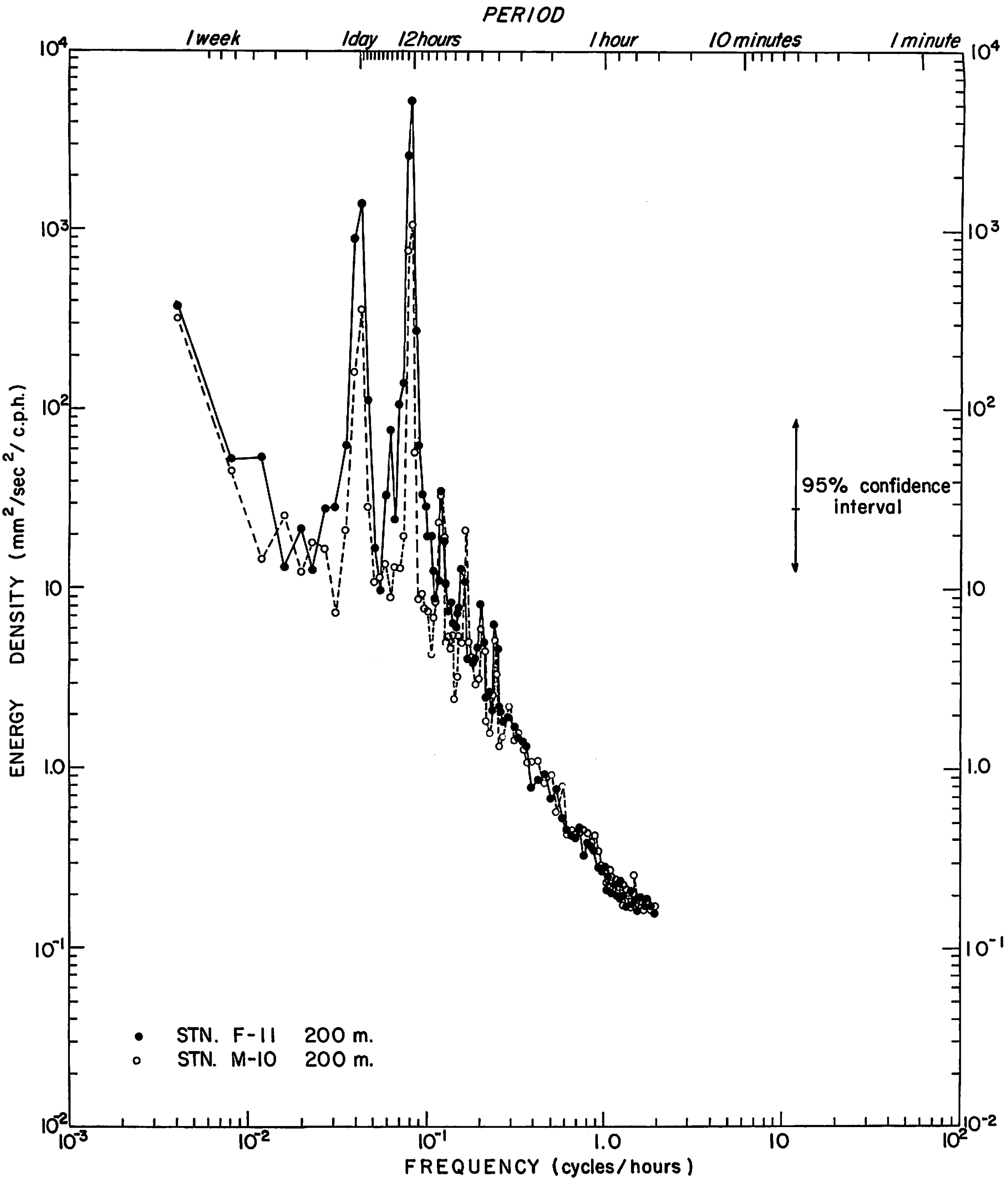


Fig. 4. Spectra energy of current vector velocities for Stations F-11 and M-10 data.

The second series of measurements were made at Stations RB-3 and RB-5 off Roberts Bank. It was a cooperative survey between POG and the Tidal and Current Surveys Division of the Canadian Hydrographic Service. Current profile measurements in the upper 100 m depth were obtained from CGS A.P. KNIGHT at hourly intervals for 5 days at RB-5, while only surface current measurements were made at hourly intervals for 4 days from CNAV LAYMORE. The latter ship also provided support for the operations of two hydrographic launches of the CHS conducting drift studies in the area.

(d) Hydrodynamical-numerical study of the tidal circulation in the Georgia-Juan de Fuca system - P. B. Crean

A study of a one dimensional hydrodynamical-numerical tidal model of the Georgia/Fuca system has been completed and a report has been prepared. The model offers considerable insight into the semidiurnal and diurnal tidal phenomena within the system. The values of the depth-mean velocities agree well with such current observations as are available. The frictional resistance in the system is considerably higher than that encountered in other coastal areas.

Mr. Crean left the Station at the end of July to commence educational leave at the University of Liverpool. There he plans to work on a more complicated model of the system.

(e) Surface circulation in the vicinity of the Fraser River plume - L. F. Giovando

Data on the surface circulation in the vicinity of Fraser River plume in the Strait of Georgia were obtained, during 1966 and 1967, by means of free-floating current followers. A total of 16 follower-tracking "sessions", involving 52 followers, was undertaken; the duration of the seasions ranged from 2 to 33 hours. Analysis of the data has generated the following conclusions:

1. Oceanographic and meteorological conditions at the onset of wind-induced surface drift significantly affecting the monitored flow could not be determined. However, it appeared that 25-knot winds acting on a very thin (1- to 2-meter) surface layer resulted in noticeable drift, whereas 10- to 15-knot winds acting in a layer about 4 meters thick did not.

2. The water from the South Arm enters the Strait as a (surface) jet. The bulk of this jet apparently does not undergo marked spreading.

3. In the absence of significant wind drift, water inflowing either during the later stages of the ebb or at high-water slack usually maintains its entrant direction until about the next low water, suggesting a basic balance between Coriolis and ebb-tidal forces during the ebb tide. The (modified) surface water can subsequently undergo a variety of motions:

   (a) Persistent northward movement (during ebb as well as flood tides) to (near) the mainland shore west of Howe Sound. It can subsequently flow westward to mid-Strait and then north-westward, rather than immediately northwestward along the mainland shore.

(b) Flow northward and eastward towards the mainland shore between Burrard Inlet and the South Arm. This movement can be manifest within one flood tide, and results perhaps from both residual and flood-tidal effects.

(c) Motion generally westward to the offing of the Canadian Gulf Islands.

4. Water entering the Strait at high-water slack possesses significantly smaller speeds than does that entering during the ebb. These lesser values are believed generally to result from dynamical restraint of the Fraser River outflow by the flood tide.

5. Water entering the Strait at low-water slack appears to turn northward immediately. It too can undergo either "persistent" northerly, or easterly movement.

6. In the absence of wind effects, water entrant during the earlier stages of the ebb can sometimes be moved southward, apparently by the combined action of residual and of ebb-tidal flow.

7. The bulk of the (modified) South Arm water attaining the shore of the Fraser River delta north of the Arm is not advected parallel to that shore.

8. The largest surface speeds apparently occur at the mouth of the Arm itself during "freshet-and-strong-ebb" conditions. Values from 3 to 5 knots are common. The speeds in the "open" Strait are generally between 1 and 2 knots, in the absence of significant winds; they can be greater during strong winds. The smallest value recorded was about 0.2 knots.

9. Other factors being equal, markedly different entrant speeds at the South Arm can apparently occur during similar conditions of Fraser River runoff as recorded at Hope, B.C. Such differences may be associated at least partly with variability in the flow of rivers entering the Fraser River west of Hope.

10. In the absence of significant winds, South Arm water might be considered generally to contribute both to the formation of, and the extension of, the portion of a "plume" north of the Arm. Wind drift would modify such a plume, and could also be the predominant reason for the extension of the plume much south of the Arm.

(f) <u>Processing of current velocity data obtained from anchored vessels</u> - S. Tabata, L.F. Giovando, J.A. Stickland, and J. Wong.

The current velocity data obtained from a number of stations in the Strait of Georgia from anchored vessels during 1967 through 1969 have been processed and outputted on computer print-outs. The computer program was written by Mr. J. Wong. It is anticipated that these print-outs will be made generally available in 1970 in form of data records.

(g) <u>Trials of towed salinity-temperature-depth recorder</u> - S. Tabata, T.M. Dauphinee (NRC, Ottawa)

A towed salinity-temperature-depth recorder designed to POG specifications is being built at the National Research Council in Ottawa under the direction of Dr. T. Dauphinee of the Applied Physics Division. It is designed for high speed measurements and at present is suited to measurements down to 200 m depth. Initial trials for its performance were conducted for 3 days in the Strait of Georgia. During the first day towing trials were made from CGS PARIZEAU. The instrument performed very well in speeds up to a maximum of 16 knots. During the following 2 days trials were conducted aboard the Canadian Coast Guard hovercraft, 021 SRN. Again, the instrument performed very well when towed at a constant depth at all speeds to a maximum of 30 knots. The large amount of information acquired during a run between Entrance Island-Sand Heads-Active Pass-Trincomali Channel within an hour or so indicated that the instrument has great potential for conducting high-speed surveys in a short time. It also appears to be an ideal instrument for making observations on high-frequency oceanographic events.

(h) <u>Howe Sound Investigation</u> - S. Tabata

During the winter of 1968-1969 the areas in the vicinity of Vancouver experienced a period of record-breaking cold weather. As polar air was prevalent over the large portion of B.C., cold, strong down-inlet winds occurred in the B.C. inlets, and particularly Howe Sound. It was believed that such a meteorological event might leave recognizable changes in the water of the Sound. On the shores of Howe Sound are located: two pulp mills, at Woodfibre and Port Mellon; one mining plant, at Britannia Beach; and one chemical plant, at Squamish. The possibility of pollution by effluent from these plants must be considered and, therefore, it is important to know the flushing characteristics of the inlet. If the down-inlet winds are strong enough it might result in significant flushing of the inlet. With this as a background, a quick survey into the inlet was made, first on 8 January 1969 aboard a hovercraft 021 (SRN-5) supplied by the Canadian Coast Guard and again on 22 January aboard the CGS PARIZEAU. A further observation was made on 28 January aboard the PARIZEAU and another on 2 May aboard the CNAV LAYMORE. Comparison of data from 8 January and 22 January 1969 indicated that during a two-week period the temperature of the upper 100 m layer of the water in the inlet had risen by about 2 C, despite the presence of a cold spell during which daily heat loss greater than about 500 g-cal/cm^2 must have occurred. The warming is almost certainly due to the inflow of the Georgia Strait water at intermediate depth. It appears unlikely that the effluent discharges from plants at Squamish and Woodfibre contributed to this warming.

2. ISENTROPIC ANALYSIS OF WATER OF NORTHEAST PACIFIC OCEAN

S. Tabata

The examination of the circulation of water in the northeast Pacific Ocean using isentropic analysis is being continued whenever opportunity permits. In addition to data from 12 cruises made by the P.O.G., others taken during 1949, 1954 and 1956 by U.S. sources are being examined. Acceleration potentials at 7 σ_t surfaces for these cruises have been computed by the Marine Sciences Branch of DEMR (Ottawa) and have been plotted on a polar-stereographic projection chart using computer facilities available locally. To date, data from all cruises mentioned above for σ_t = 26.0 through 27.2 have been plotted and contoured. It is anticipated that an atlas containing these charts will be produced and outputted as joint FRB-MSB report within a few years.

3. OCEANIC - COASTAL PROGRAM

A.J. Dodimead, R.H. Bigham

Studies primarily to define the seasonal and year-to-year variations in the physical and chemical properties of the waters extending to approximately 200 miles off the coasts of British Columbia and Washington were continued. The study is partly designed in support of investigations on development of strong and weak groundfish year-classes during some years. In 1969, the field program consisted of 3 cruises. The first was a short but intensive survey of a small area overlying the continental shelf north of Barkley Sound, undertaken in early March and consisted of 3 sections extending from the coast to the continental slope. The second and third cruises were approximately 3-week cruises in April and in October, similar in extent to those undertaken in 1967 and 1968.

(a) Depth of mixed layer - April 1968.

In April 1968, the thickness of the surface mixed layer varied between 0 and 90 meters, with the shallowest depths occurring near the coast of Vancouver Island (Fig. 5A). These depths are considered to be representative of mid-winter and early-spring conditions. There is a marked similarity in the distribution of these isopleths and of the surface isohalines, particularly seaward of Vancouver Island (cf. Fig. 5A and 5B). The main features of the gradients are nearly coincident, and the shallowest mixed-layer depths are associated with the lowest surface-salinity values.

The formation of the mixed layer is considered to be due to wind mixing and to convective overturn resulting from cooling and evaporation. The depth to which these processes extend will depend on the stability within the water column. It would appear that, off the coast of Vancouver Island, the prime factor limiting the depth of mixing during late winter and early spring is the salinity of the surface waters.

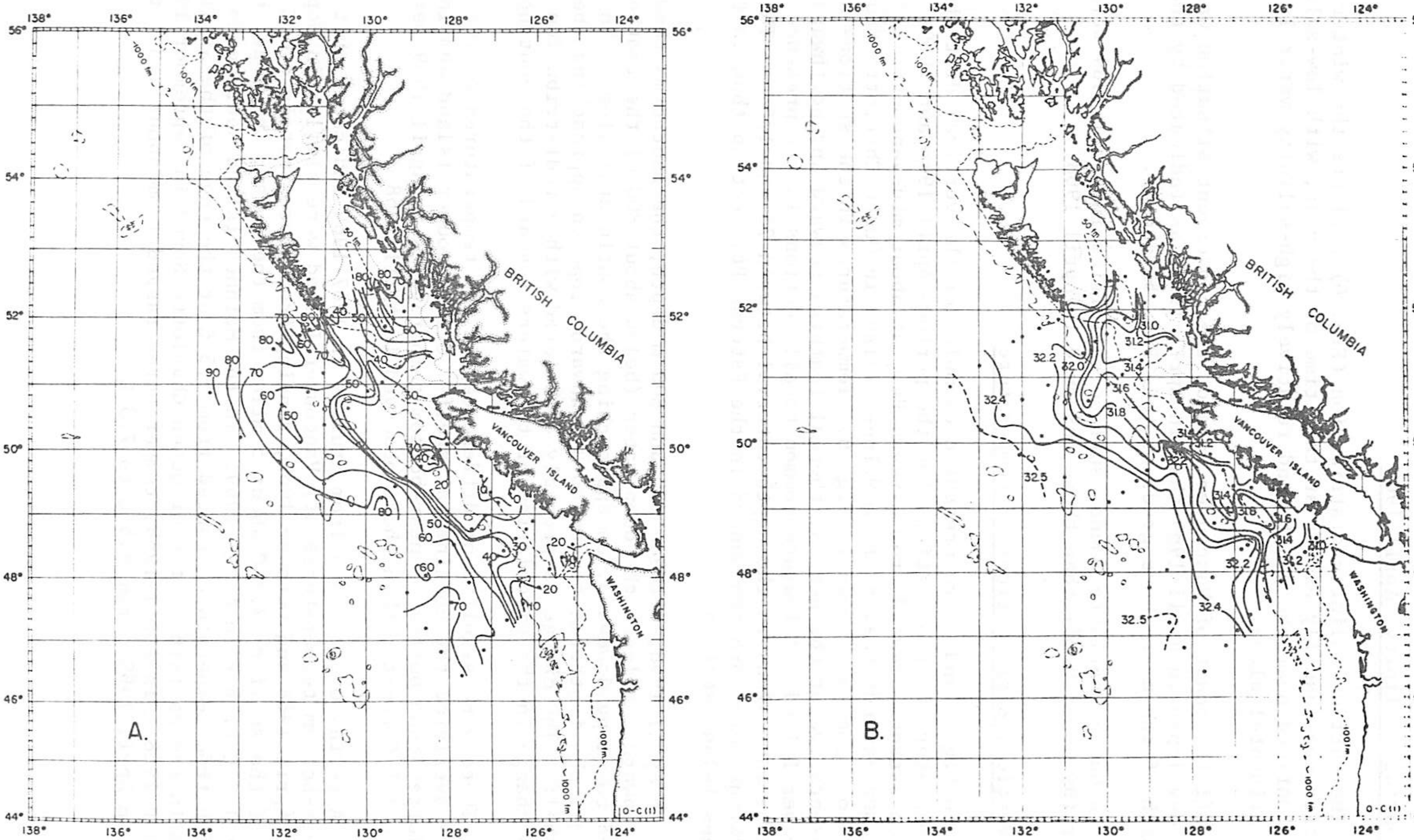


Fig. 5. (A) Depth (m) of mixed layer, and (B) surface salinity (‰), April 1968.

(b) Surface salinity, April 1969

The surface salinity distribution (Fig. 6) reflects the winter convergent situation that usually exists at this time of the year, with low-salinity water confined near the coast, and relatively high-salinity water lying near the continental slope.

Off the coast of Vancouver Island, the convergent situation was more fully developed in April 1969 than in April 1968, as indicated by the strength of the near-shore gradient (cf. Fig. 5B and 6).

In Queen Charlotte Sound, surface salinities in April 1969 were slightly higher (by about 0.5‰) than those observed in April 1968.

(c) Vertical distributions of temperature

In Fig. 7 and 8 are presented examples of the vertical distributions of temperature in two sections for the periods April 1968 and 1969. One section extends seaward from Estevan Pt., at about mid-Vancouver Island, and the other extends seaward from McInnes Island in Queen Charlotte Sound. Their locations are shown in Fig. 6. Temperatures in the sections are representative of the general thermal features seaward and northward of Vancouver Island. A feature common to all sections is the presence of temperature inversions in the depth interval between 75 and 175 m. The temperature inversions were more pronounced in the Estevan Pt. section than in the McInnes Island section.

In April 1968, between 250 and 800 m depth, the isotherms tended to slope upward, while in the deep water (below about 800 m) the isotherms tended to slope downward, on approaching the continental slope. In April 1969 all the isotherms tended to a downward slope on approaching the continental shelf. The change is probably associated with a redistribution of mass and a change in the circulation of the waters seaward of the continental slope.

There were significant differences in the temperatures of the bottom waters overlying the continental shelf. Off Vancouver Island and in Queen Charlotte Sound bottom or near-bottom temperatures in April 1969 were from 1.0 to 1.5 C greater than those observed in April 1968.

A review of the data from cruises in 1967-1969 indicates that bottom or near-bottom temperatures off Vancouver Island were similar in September 1967, April 1968 and October 1968, ranging from approximately 6.0 C at the edge of the shelf to 7.2 C about 5 miles from the coast; however, they were about 1.0 C higher in April 1969. In the McInnes Island section to the north, shelf bottom temperatures ranged from 5.5 C at the edge of the shelf to 6.2 C in the eastern sector of Queen Charlotte Sound in September 1967 and October 1968. In April 1968, temperatures ranged from about 4.3 C to 6.8 C and, in April 1969, from 5.5 C to 7.3 C.

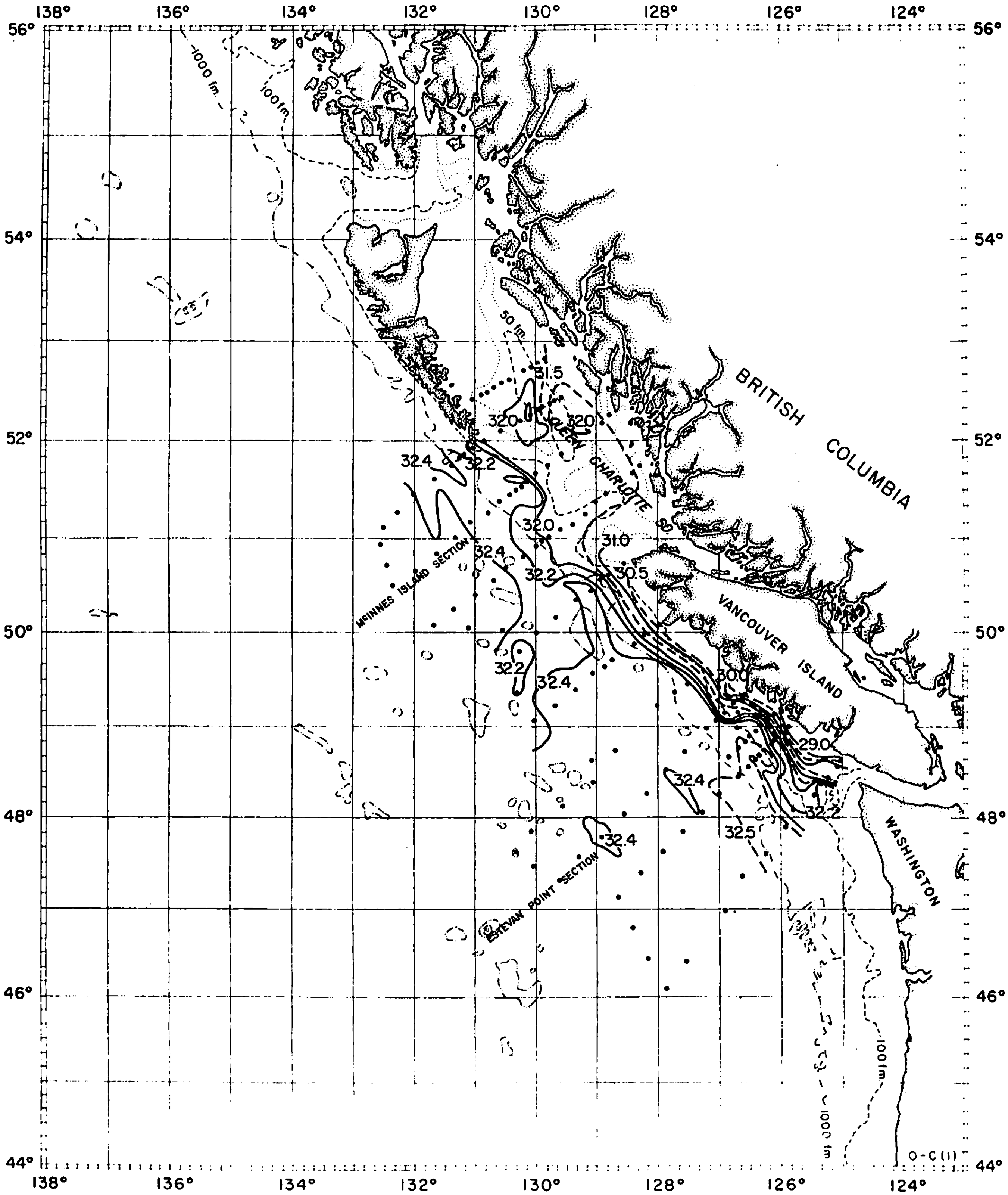


Fig. 6. Surface salinity (‰), April 1969.

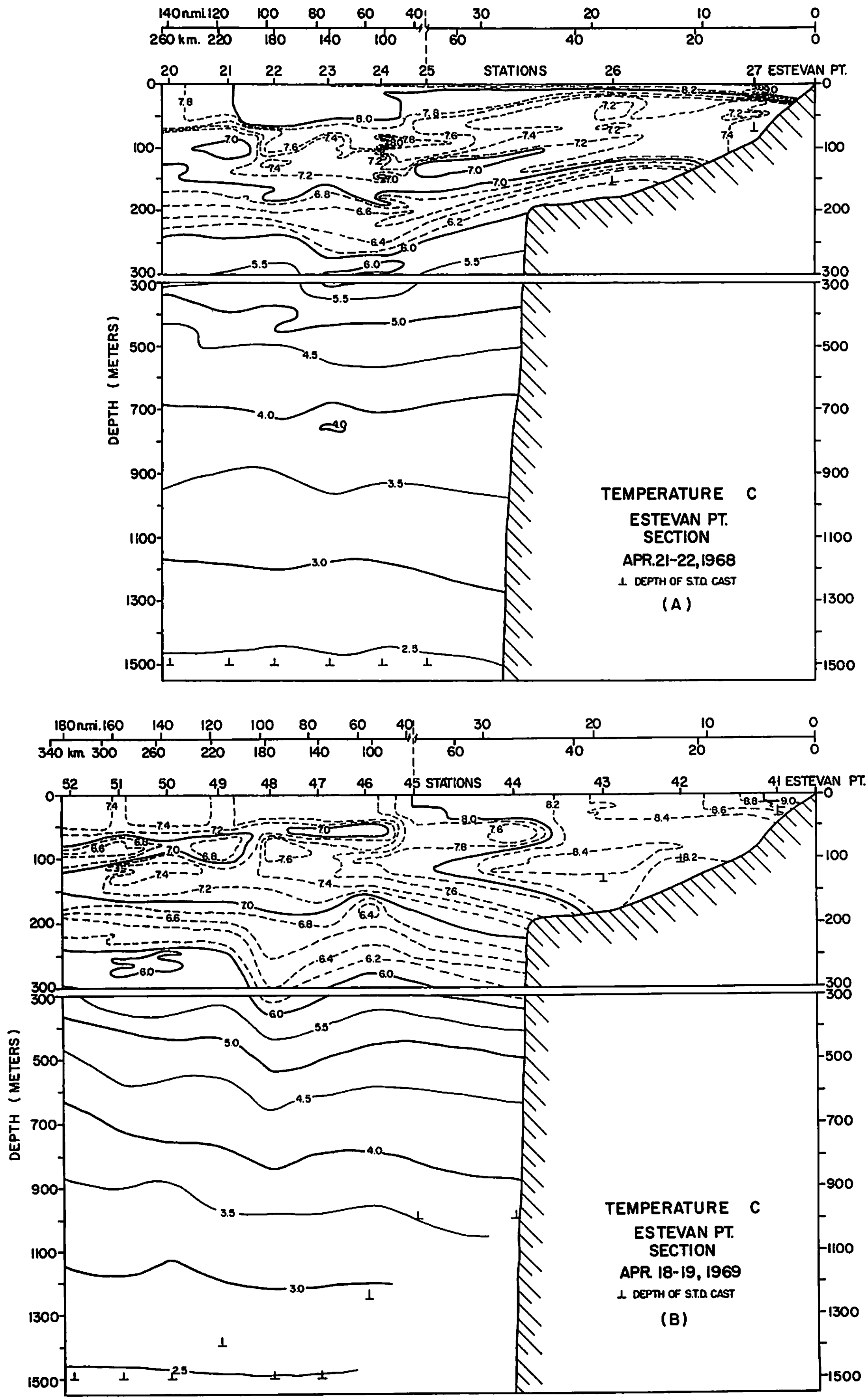


Fig. 7. Temperature (C) distribution along Estevan Pt. section, April 1968 and April 1969.

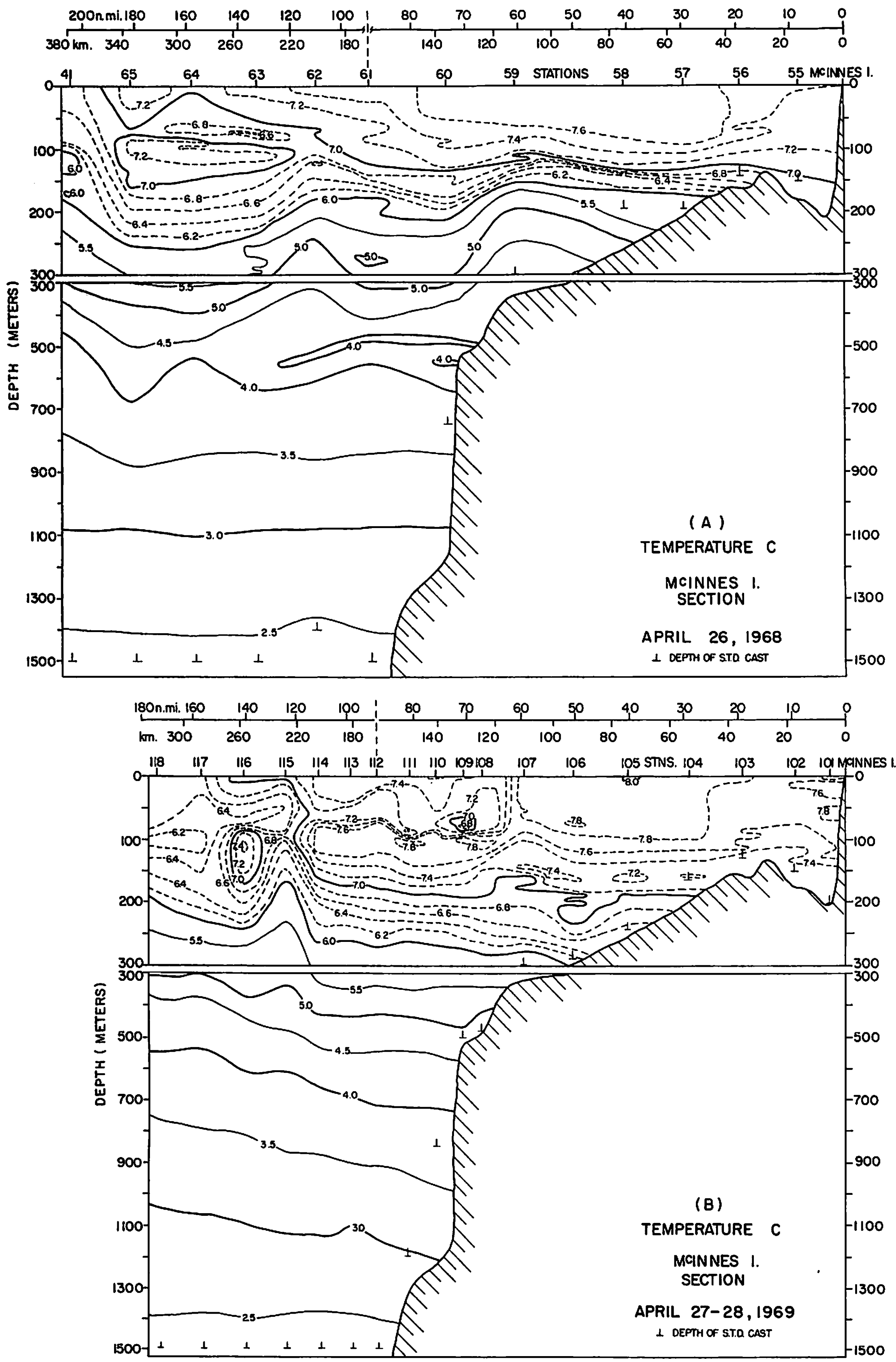


Fig. 8. Temperature (C) distribution along McInnes Is. section, April 1968 and April 1969.

4. OCEAN STATION P - LINE P

(a) Program, 1969 - C.A. Collins, D.A. Healey, C. DeJong

The regular program of oceanographic observations from the weatherships CCGS VANCOUVER and CCGS QUADRA was continued during 1969. Oceanographers were present on the nine patrols in 1969. Cruises are listed in Table I - Ocean Station P - Line P, page 12. The program included one Nansen bottle cast per week at Station P to 4200 m to determine vertical profiles of temperature, salinity and dissolved oxygen. A continuous recording salinity-temperature-pressure (STP) system was used to a maximum pressure of 1500 db except on cruise 3 for which no instrument was available. STP casts were scheduled daily for cruises 4, 5 and 6, twice-weekly for cruises 2, 7, 8 and 9, and for each station en route to and from Station P (Line P). A survey of eight stations around Station P was reinstituted during cruise 2 and the STP was also used for these stations. Observations have been graphically summarized in Table IV.

Biological observations were scheduled as follow:

(i) zooplankton observations

- a. daily, a 150 m vertical plankton haul
- b. twice during a cruise, a 1200 m vertical plankton haul
- c. nine times during a cruise, a 10-minute horizontal plankton haul
- d. weekly, a Van Dorn bottle cast for micro-zooplankton

(ii) productivity observations

- a. every second day, surface measurements of photosynthesis and of plant pigment
- b. three times during a cruise, a Van Dorn bottle cast for photosynthesis, plant pigment and nitrate measurement
- c. surface nitrate samples at each Line P station.

Biological data are processed by the Environmental Research Group, Biological Station, Nanaimo.

When weather permitted, the crews of both ships made bathythermograph observations every three hours to coincide with routine meteorological observations. Daily samples of surface water for salinity determinations were also collected by the crew.

The following were collected for other institutions:

(i) surface samples on each patrol for analysis by the Inland Waters Branch, DEMR;

(ii) during cruise 2 and 4, ten 15-gallon samples between 50 and 3000 m were obtained and treated for C^{14} analysis by Dr. Fairhall, University

TABLE IV. STATION P AND LINE P OBSERVATIONS FOR 1969

4200 M - NANSEN BOTTLE CAST

Cruise number	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	Grid P
1	x	x					
2	x	x	x	x	x	x	x
3	x	x	x		x	x	x
4	*	x	x	x	x	x	x
5	x	x			x	x	x
6	x	x	x	x	x	x	x
7	x	x	x	x	x	x	
8	*	*	*	*	*	*	
9	Not yet available						

Note: * = asterisk indicates STP data available to 1500 m

LINE P STATIONS

Cruise number		1	2	3	4	5	6	7	8	9	10	11	12
1	out							x					
	in	x	x	x	x		x	x	x	x	x		
2	out	x	x	x	x	x	x	x	x	x	x	x	x
	in		x	x	x	x	x		x	x	x		x
3	out									x			
	in		x	x	x	x	x	x	x	x	x	x	x
4	out	x	x	x	x	x							x
	in	x	x	x	x	x	x	x	x	x	x	x	x
5	out	x	x	x	x	x	x	x	x	x	x	x	x
	in												
6	out	x	x	x	x	x							
	in			x				x					
7	out	x	x	x	x	x	x			x	x		x
	in												
8	out												
	in												
9	out						x				x	x	

x - indicates a completed station.

of Washington; some samples for chlorophyll measurements along line P were obtained for Dr. Anderson, University of Washington.

(iii) surface and rainwater samples were obtained for Scripps Institution of Oceanography.

Observations for the U.S. Atomic Energy Commission and the U.S. Naval Radiological Laboratory were discontinued during 1969.

During cruise 6, additional biological data were obtained by personnel from the National Museum of Natural Sciences, the University of Ottawa, and the University of Victoria. Eleven midwater trawls were made to depths of 950 m. Depths of 600-800 m seemed most productive for mesopelagic fishes. Several of the specimens obtained were rare, and at least one was probably an undescribed species. Seven trawls were made with a surface Neuston net and sauries and blue lantern fish were obtained; experimental work was carried out on the bio-luminescence of the lantern fish. Other samples were obtained to study the effects of diurnal light changes on phytoplankton.

During cruises 2, 4 and 6, additional physical oceanographic data were obtained. Water samples were gathered near the ocean bottom with Nansen bottles and vertical STP profiles were obtained to study internal tidal waves as well as higher-frequency internal waves. A near-bottom current meter was also used on cruise 4.

Collection and analysis of physical oceanographic data was facilitated by a Hewlett-Packard data acquisition system on cruise 4 and an STP digitizer on cruises 4 and 6. Satellite navigation equipment was also successfully operated on cruise 4.

(b) <u>Studies of data</u> - C.A. Collins

In addition to the analysis of data collected during the past year, preliminary analysis of selected sets of data gathered in past years has begun. Data include surface temperature and salinity observations, seasonally-averaged Line P data, deep data at Station P and Station P bathythermograph data for 1960-69.

A frequency distribution for observed surface temperature and salinity is given in Fig. 9. Samples were obtained daily since 1956. The frequency distribution is trimodal; secondary modes occurred at 32.80‰, 5.5 C and 32.60‰, 13.0 C. The most frequently observed T-S pair (primary mode) was 32.60‰, 6.0 C. Mean values for each month, as well as a total mean are also indicated in Fig. 9 and an annual oscillation of salinity as well as temperature can be observed. The surface waters had lowest temperature and highest salinity in March, were least saline in October, and had the highest temperature in August. The range of the monthly mean salinity values was 0.12‰ and the range of the monthly mean temperature values was 7.8 C. The total mean for the population, 8.3 C, 32.65‰, was not "representative" of the distribution. Preliminary analysis indicates the secondary mode at low temperatures was due to lower salinities in the years 1959-61 and 1964-65.

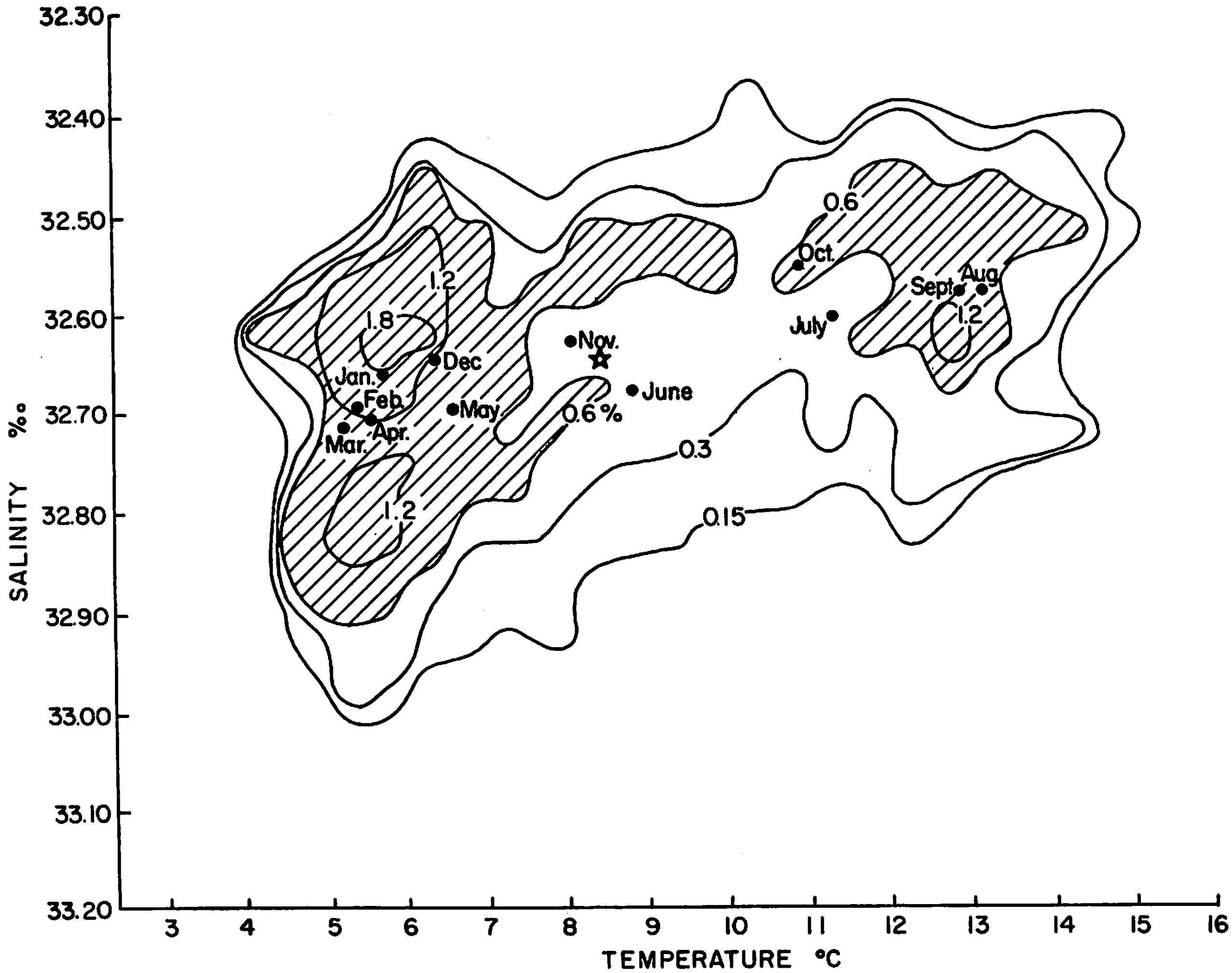


Fig. 9. Frequency distribution for Station P surface temperature and salinity observations. Numbers on isolines represent the percentage of the total number of observations. Data were obtained in years 1956-1969. Monthly means and the mean of all data (a star) are also indicated.

Three sections for averaged Line P temperature, salinity, and specific volume anomaly are presented in Fig. 10. Data at standard depths were grouped by season and averaged; each seasonal average was then weighted equally to produce an overall average. Features easily noted in the temperature section are: the steady, upward rise of the 3.9-7.0 C isotherms to the west; the fact that the 8-10 C isotherms are deepest at 127°W and slope upward both to the east and west.

In contrast to the westward-rising isotherms, most isohalines varied little in depth from 126°W to 145°W. At depths below 450 m, maximum salinity values at a given depth were found at 129°W and at 145°W; the longitude of the maximum depth of an isohaline increased with increasing salinity, from 133°W for the 34.10‰ isohaline to 137°W for the 34.35‰ isohaline. Isohalines at the bottom of the halocline, 33.90‰ and 33.80‰, slope downward to the west while those at the top of the halocline, 32.60-31.50‰, slope upward to the west; the result is a steady decrease in the intensity of the halocline to the west, a well-documented feature of the northeastern Pacific Ocean.

The specific volume anomaly section illustrates the effects of temperature and salinity on the field of mass. Isosteres equal to or less than 140 rise to the west. A decrease in the rate at which isosteres 80 to 140 rise to the west occurs at 129°W. For isosteres 100-75 a similar point occurred at 141°W. The depth of isostere 180 was nearly constant while isosteres 200-300 rose both west and east of 131°W. Isosteres 325, 350 and 375 appeared only close to shore.

Analysis of 125 surface-bottom profiles of salinity, oxygen and temperature for Ocean Station P is also progressing. This work has benefited from analysis of the same data set by Mr. Stewart Rupp, who concluded that average properties near the bottom were 1.50 C, 34.69‰, and 3.30 mℓ/ℓ and that the uncertainties of published salinity and oxygen values were 0.012‰ and 0.10 mℓ/ℓ. Collection of additional deep data is continuing, and thermometers have been recalibrated to give results to thousandths of a degree; on patrol 4 the deep temperature minimum, 1.50 C, was observed between 3800 m and 3900 m.

Bathythermograph data for Station P for 1960-67 have been digitized by the National Oceanographic Data Center of the United States and listings have been obtained. Current bathythermograph data are being digitized by Scripps Institution of Oceanography. These data are being statistically summarized by Mr. Ken Abbott-Smith using computer facilities at the University of Victoria.

Analysis of data collected from the grid surveys around Ocean Station P was undertaken by Miss A. Huyer.

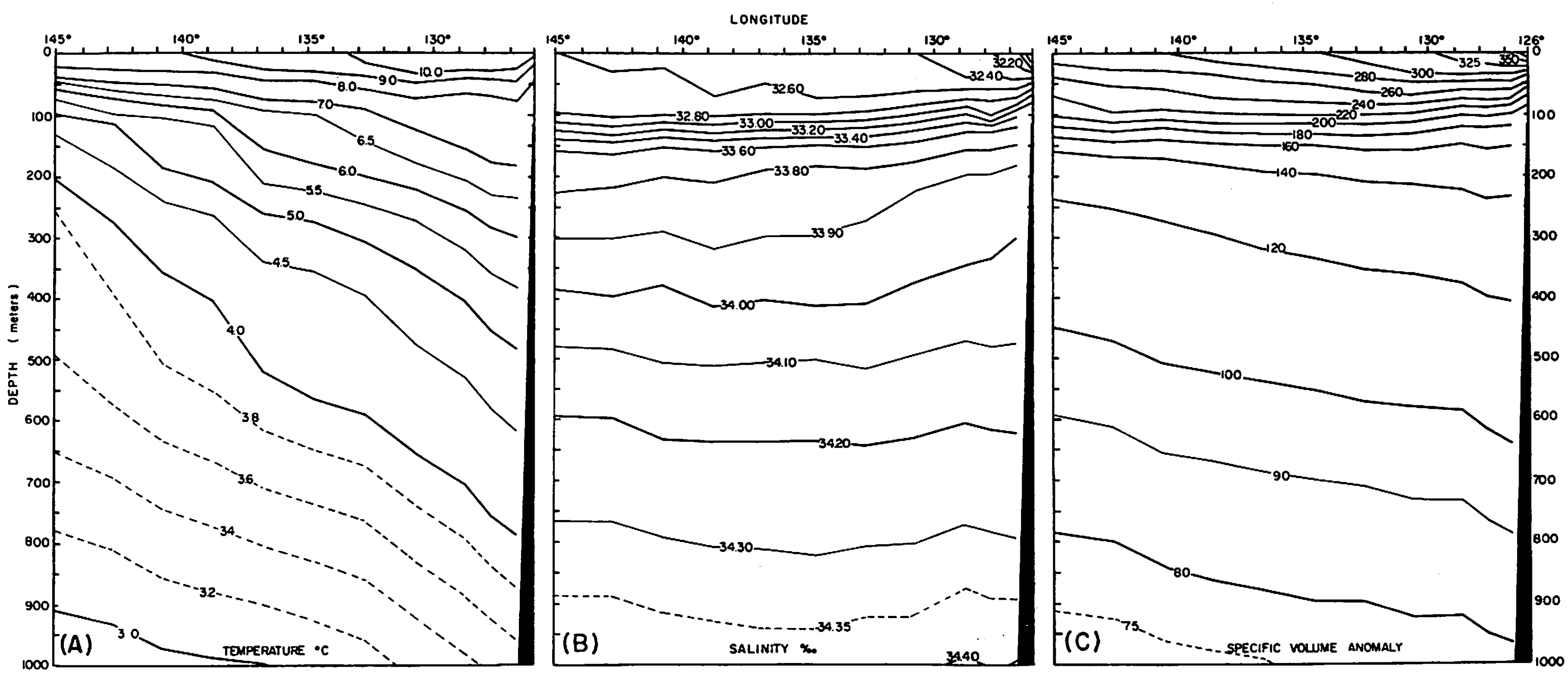


Fig. 10. Hydrogeography along Line P. Data used were obtained by equally weighting seasonal averages to obtain an overall average. Data were obtained in the years 1959-1968. Sections are presented for (A) temperature, (B) salinity, (C) specific volume anomaly.

(c) Deep-sea instrumentation - C.A. Collins

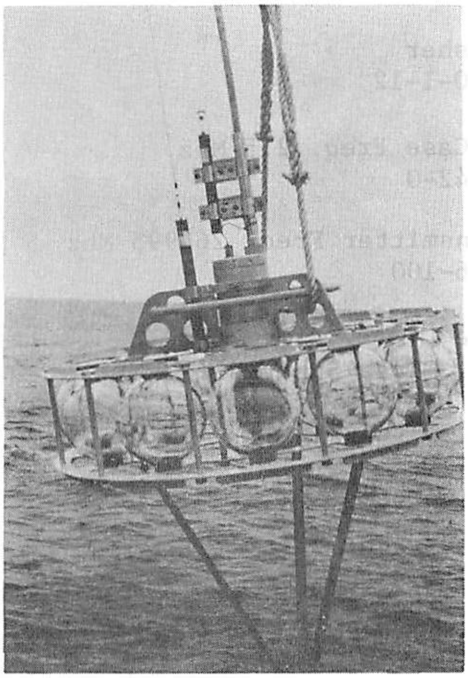
During cruise 4, a free-fall current meter system was twice launched and recorded (see Fig. 11). The system is sketched in detail in Fig. 12, and consisted of a buoy on which was mounted 2.5 Mhz and 27 Mhz radio beacons and a flashing light and from which was suspended a current meter and a release device. A corrosive link was also placed in the line in case the release device failed. The system was designed to sink to the bottom, record current velocity, and to return to the surface at a preset time. The rate of fall and ascent of the instrument was about 0.8 m/sec; this meant that it took the buoy about 1.3 hours to reach the bottom.

The system was first launched on 29 May and was preset to surface at 0900 on 31 May. The system was detected on the surface at 0910 31 May with the 27 Mhz beacon (the delay in receiving the 2.5 Mhz signal was due to the fact that the hollow fiberglass antenna must drain completely.) Recovery was made using the ship's RDF (2.5 Mhz); it took about one hour of searching to find the buoy in foggy weather. The system was on the bottom a total of 40 hours and was recovered (despite southerly winds) three miles south-southwest of the launch point.

The system was again launched on 4 June and was set to be on the ocean bottom for 92 hours. After approximately 62 hours a signal was noted by the watch officer (who was checking twice during the four-hour watch) on 2.5 Mhz; we checked at this time and also noted a signal at 27 Mhz. Again recovery was made using the ship's RDF. Radar detected the surface buoy at six miles (it was nearly calm) and it was spotted visually at a distance of two miles. After transmitting for approximately three hours, the 2.5 Mhz transmitter stopped and later smeared across a rather wide frequency band; the cause of the transmitter failure was a faulty transistor. The fact that the buoy surfaced early was the result of the failure of the corrosive magnesium link. (The link was a flamed magnesium rod of 11/16" diameter; 5/16" diameter holes were drilled 1/2" from each eand and through these passed an unthimbled eye of stainless steel BT wire.) The buoy was recovered one mile to the north of its launch point. All instruments were in excellent condition after surfacing.

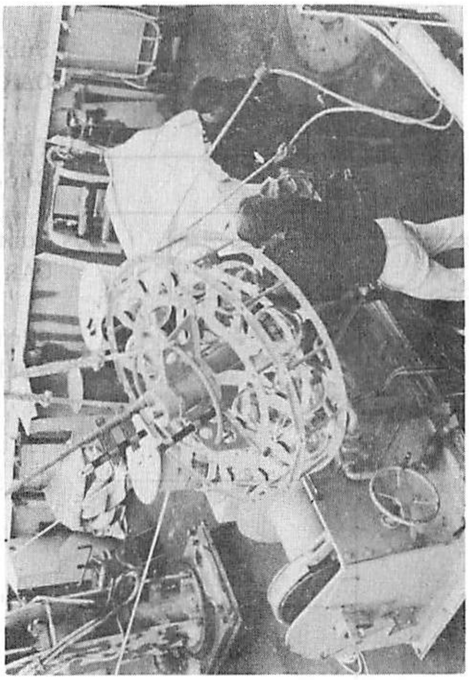
The current meters recorded in the "continuous mode" so that speed direction and instrument tilt were recorded every seven seconds. Each deployment event-- launching, recovery, settling and rising from the bottom -- was clearly indicated in the resulting record. As the meter sank to, or rose from, the bottom, the direction vane rotated through 360° about once every 500 m and indicated speeds were 0.1 knot. On the bottom, direction values became steady and speeds dropped to 0.05 knots or less. At the surface, indicated speeds increased to 0.5 knot or more, tilts occurred, and the direction stopped its steady rotation and became more variable.

(A)



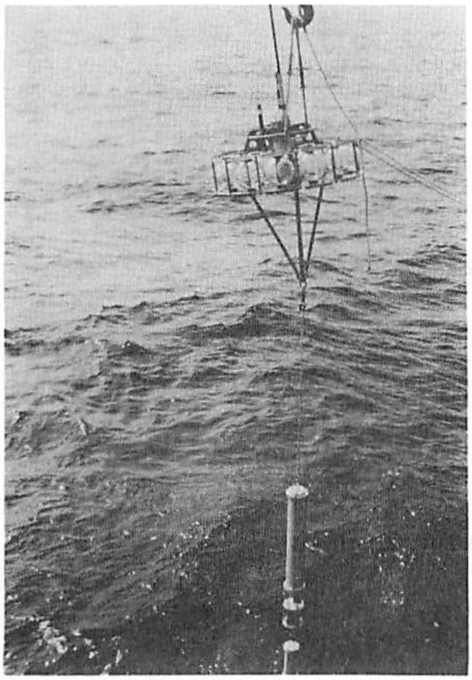
FLOTATION DEVICE

(B)



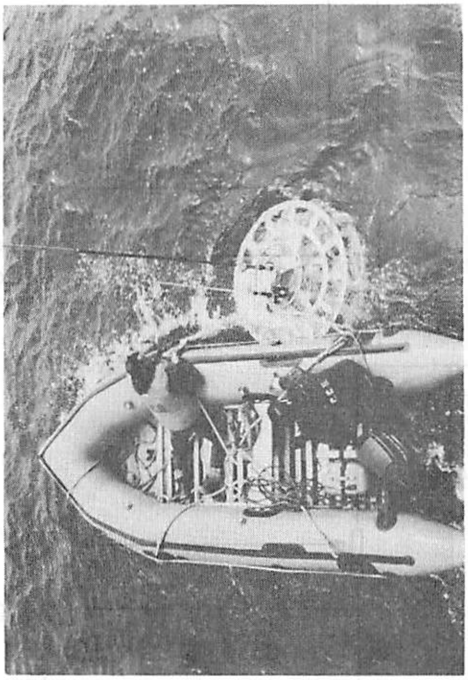
PREPARING EQUIPMENT FOR LAUNCHING ON AFT DECK OF C.C.G.S. QUADRA.

(C)



READY FOR LAUNCHING

(D)



RECOVERY BY SHIPS CREW

Fig. 11. Deep-sea free-fall current meter system: (A) flotation device; (B) preparing equipment for launching on the after deck of the CCGS QUADRA; (C) ready for launching; (D) recovery by ship's crew.

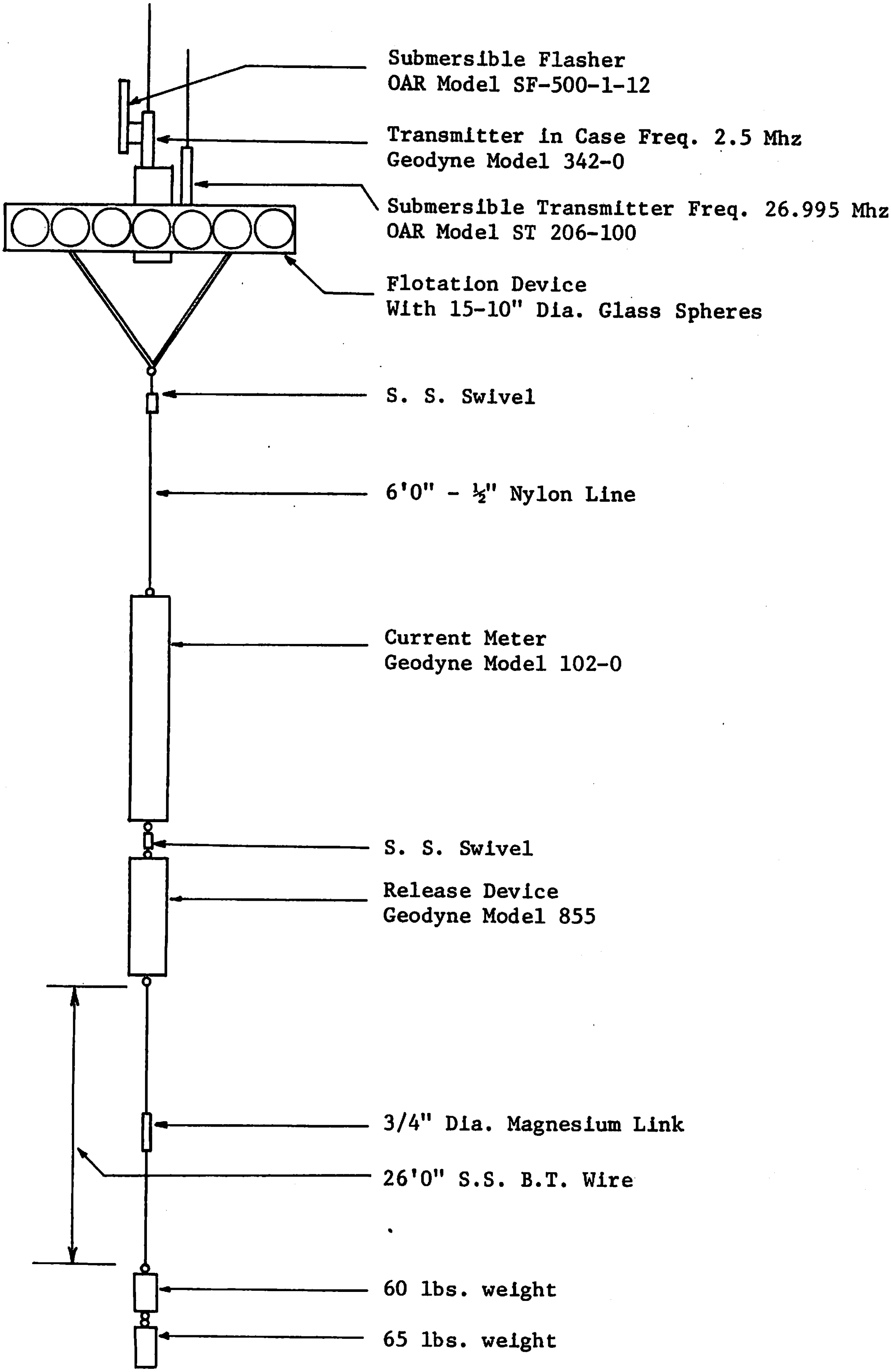


Fig. 12. Schematic diagram of deep-sea free-fall current meter system.

Preliminary analysis of the velocity records indicates that the mean bottom velocity for the first period, 29-31 May,was 0.015 kt, 073°; the mean velocity for the second period, 4-7 June, was 0.002 kt, 277°. The measured velocity should be an indication of barotropic transport and so the data confirm that the barotropic transport is time dependent. Other features of the velocity data were that flow to the southwest seldom occurred during 29-31 May and that flow to the northeast seldom occurred during 4-7 June. A semidiurnal oscillation occurred in the data and the amplitude of the associated speed variation was 0.005 knots.

Future experiments will measure horizontal and vertical coherence as well as obtain longer time series which will include other parameters.

(d) Compatibility of STD and hydrographic cast data - D.A. Healey

During use in the field, the calibration of the Bissett-Berman model 9006 and model 9040 salinity-temperature-depth instruments must be continually checked. As these instruments are being used to replace Nansen bottle casts, it is important that the two sampling methods yield compatible results. Nansen bottles are placed immediately above the STD and tripped when the STD is at its maximum depth. In addition a surface sample is obtained while the STD is at the surface, so that two values of temperature and salinity are available for checking each STD cast. During each survey, a number of hydrographic casts are made immediately before or after STD casts, giving vertical profiles of temperature and salinity for comparison.

Immediately following laboratory calibration, it has been found that STD data approximate hydrographic data within the specifications provided by the manufacturer (salinity accuracy ±0.03‰, temperature accuracy ±0.05 C). By comparing the two types of data and applying a correction factor to the STD data, the two data sets may be made to agree more closely. However, surface and maximum depth comparisons are of value only when the STD error is constant, or linear with depth.

Comparison of data collected during June 1969 from CCGS QUADRA showed a somewhat poor agreement between STD and hydrographic data. The 300 m STD and surface Nansen bottle casts were taken every 1½ hours for over 100 hours. Figure 13 compares surface temperature observations. Of 27 pairs of observations, 5 pairs differed by more than 0.05 C. The 3 m separation of the STD and Nansen bottle and the presence of a vertical temperature gradient close to the surface can account for reversing thermometer temperatures higher than corresponding STD temperatures, but higher STD temperatures cannot be explained. Figure 14 compares salinity values at the surface. The salinity samples obtained from Nansen bottles are all within ±0.02‰ of 32.51‰, but the STD salinities fluctuate wildly, with an extreme value of 33.15‰. These salinity errors are normally constant with depth to 300 m, but in a significant number of casts the error is non-constant.

A salinity shift has been observed on previous cruises in about five per cent of stations. Its occurrence has been intermittent, and has never occurred in two consecutive casts. These results have made it necessary to check STD calibrations with at least two points for each cast. The calibrations deteriorate with prolonged instrument use.

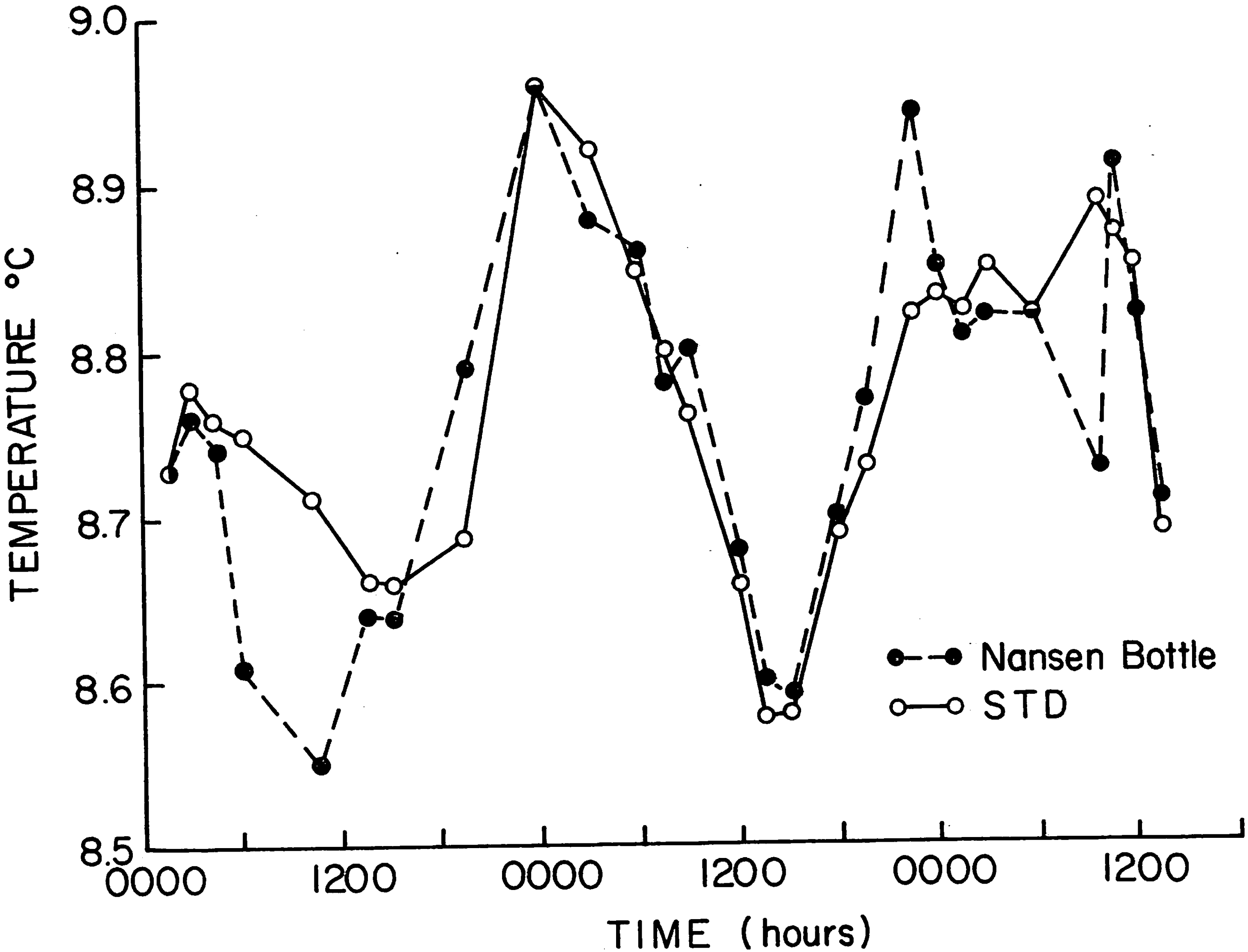


Fig. 13. A plot of surface temperature values obtained from Nansen bottle and STD casts.

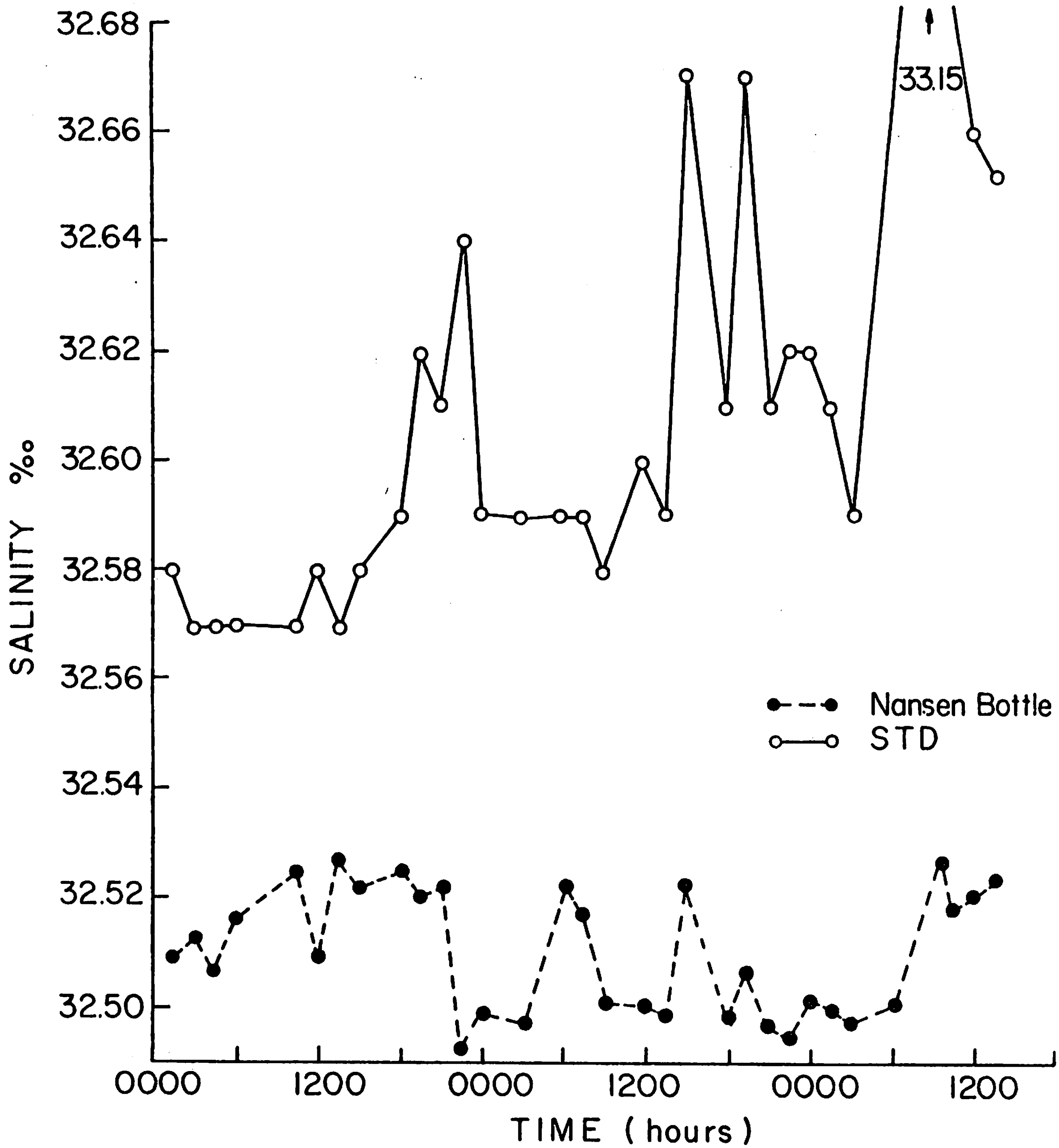


Fig. 14. A plot of surface salinity values obtained from Nansen bottle and STD casts.

(e) <u>Intercomparison of in-situ salinity-temperature-depth instruments</u> - D.A. Healey and C. DeJong

A two-week intercomparison cruise was carried out in cooperation with Dr. R. Trites of the Bedford Institute. A Bissett-Berman model 9040 STD, an NRC STD and a German-manufactured Bathysonde were compared in the western North Atlantic from CSS DAWSON, September 2-12. Each of the instruments was lowered before and after hydrographic casts. The Bissett-Berman and NRC units were lowered in conjunction with the tripping of bottle casts with close spacing of bottles through detailed temperature and salinity structures. An attempt was also made to compare the instruments in uniform temperature and salinity conditions. All data were logged with a digital data logging system, except when two of the STD units were used simultaneously.

Preliminary results indicate that each instrument measured temperature rather well (when compared to reversing thermometer temperatures). The Bathysonde measures temperature and conductivity independently, but has no facility (internal) to determine salinity from the two. The NRC unit measures temperature and conductivity and converts the two to temperature-compensated salinity. It remains to compensate salinity for pressure. The Bissett-Berman STD has a direct output of both temperature and salinity, making its analogue traces the easiest to interpret. In regions of strong temperature gradient, the NRC STD seems to compensate for the temperature changes much better than the Bissett-Berman, which may give errors as large as 0.40‰ salinity in temperature gradients of 2 C/m. As a survey tool, the Bathysonde has little use, as the conductivity output is dominated by temperature, so that salinity changes are not obvious from the analogue traces. The Bissett-Berman unit is the easiest to operate, but the NRC underwater unit is the only one which can be handled easily by one man.

5. STATISTICAL ANALYSIS OF TIME SERIES

C.A. Collins

During 1969, analysis of sea level data for Tofino, Tasu Sound, Prince Rupert and Bella Bella for May 1962 to May 1964 was undertaken. Data were numerically tapered to remove tides and then decimated to one observation per day; autospectra, phase and coherence square are illustrated in Fig. 15. The slope of the autospectra (log energy density vs log frequency) was between 4/3 and 5/3. At no single frequency did the energy density dominate the autospectra; values of energy density which were statistically greater than the spectral continuum occurred at 0.06, 0.135 and 0.20 cpd for most stations. A statistically significant peak also occurred at 0.33 cpd for Tofino, Tasu Sound and Bella Bella sea level series and at 0.38 cpd for Prince Rupert sea level.

Phase values at most frequencies indicated that the lag between Tasu Sound and Prince Rupert sea level fluctuations was least and that the lag between Tasu Sound and Tofino sea level fluctuations was greatest. This relationship was true at 1.34 and 0.20 cpd, and is the sort of phase relationship one would expect associated with atmospheric fronts moving to the east from the northeastern Pacific Ocean. At 0.06 and 0.33 cpd, the relationship was reversed, i.e., the sea level fluctuations proceeded from south to north.

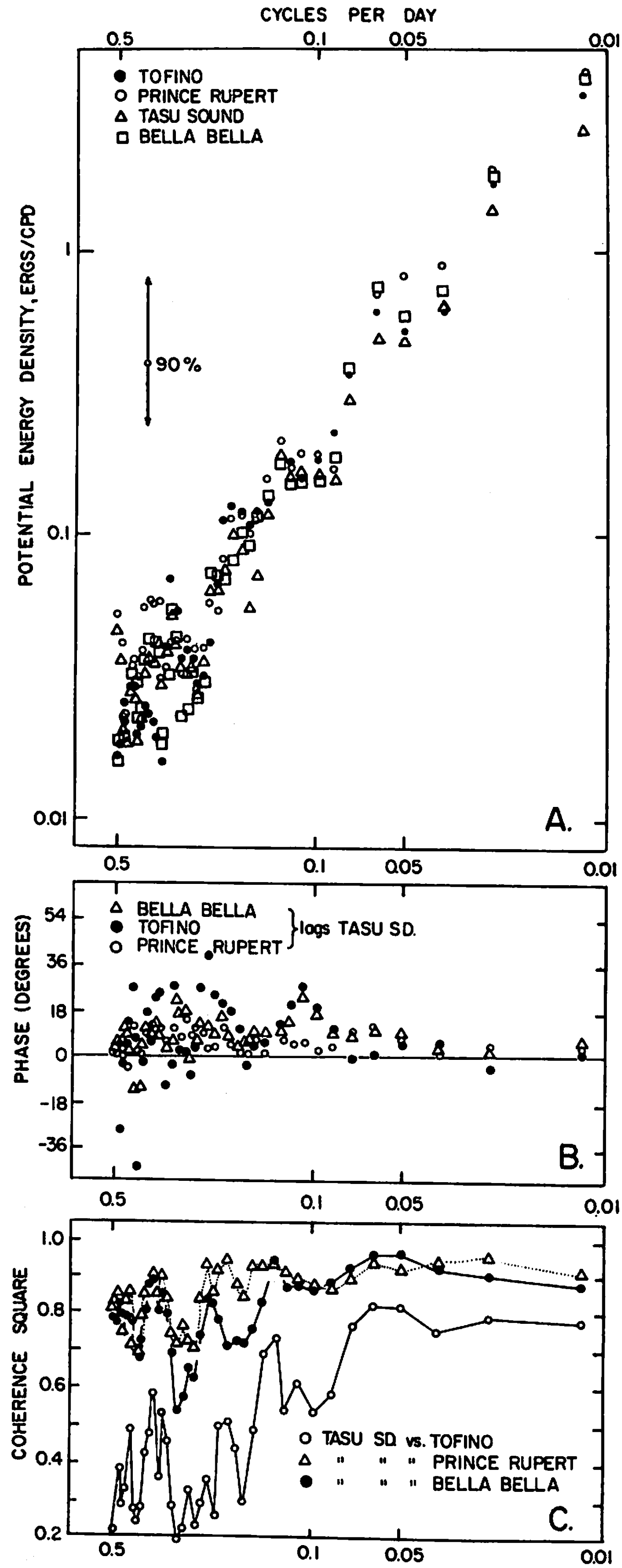


Fig. 15. 0.01-0.50 cycle per day sea level fluctuations for Tasu Sound, Tofino, Prince Rupert and Bella Bella. The autospectra are given in A; the phase with respect to Tasu Sound is given in B; and in C are presented coherence square between Tasu Sound and other sea level stations.

Coherence square values indicated that, in general, sea level fluctuations at Tasu Sound were most coherent with those at Prince Rupert and least coherent with those at Tofino (coherence square values are significantly greater than zero at the 90% level if they exceeded 0.25). Peaks in the coherence square vs frequency curves occurred at 0.06, 0.135 and 0.20, and for the 0.33 to 0.38 cpd band, i.e., at the same frequencies as autospectral peaks.

This study is proceeding; the next step is to utilize atmospheric pressure data and compute cross spectra for the pressure-sea level time series.

Another time-series analysis study concerned numerical demodulation of current velocity time-series to see how the kinetic energy at the inertial frequency varied with time. Data were obtained at Oregon State University and were partially described in my Ph.D. dissertation. One hundred to 240 erg peaks in the time variation of kinetic energy were detected at the inertial frequency. These peaks were superimposed on a noise level of about ten ergs although values as low as three ergs were obtained. These peak values were obtained only in the velocity time-series obtained above the pycnocline. A statistic for the coherence between the two hodographs did not seem very useful.

The demodulation technique and results are given fully in a report submitted to file.

Spectral analysis of six-week averaged hydrological variables observed at Ocean Station P have been commenced; it is hoped that a preliminary report describing first results can be submitted to file early next year.

6. SUPPORT OCEANOGRAPHY

R.H. Herlinveaux and Others

(a) Seamount Investigation

During 1969 a joint project with Defence Research Establishment Pacific was undertaken to determine the feasibility of using those seamounts situated off the British Columbia and Washington coasts as observation platforms. Four trips were made to Bowie Seamount to carry out a bathymetric study and to collect rock samples and bottom organisms. Canadian Forces divers were used on two occasions, to obtain photographs and to collect samples. Fish were caught by the crew of CSS PARIZEAU and were brought back for analysis. Oceanographic observations were made over, and in the vicinity of, the seamount. A current meter was operated for 11 hours at 20 m depth while the ship was at anchor over the seamount.

The fish on Bowie Seamount were so numerous (Fig. 16) that the divers had to push them out of the way in order to take photographs. It is possible that these fish make up a resident and isolated population.

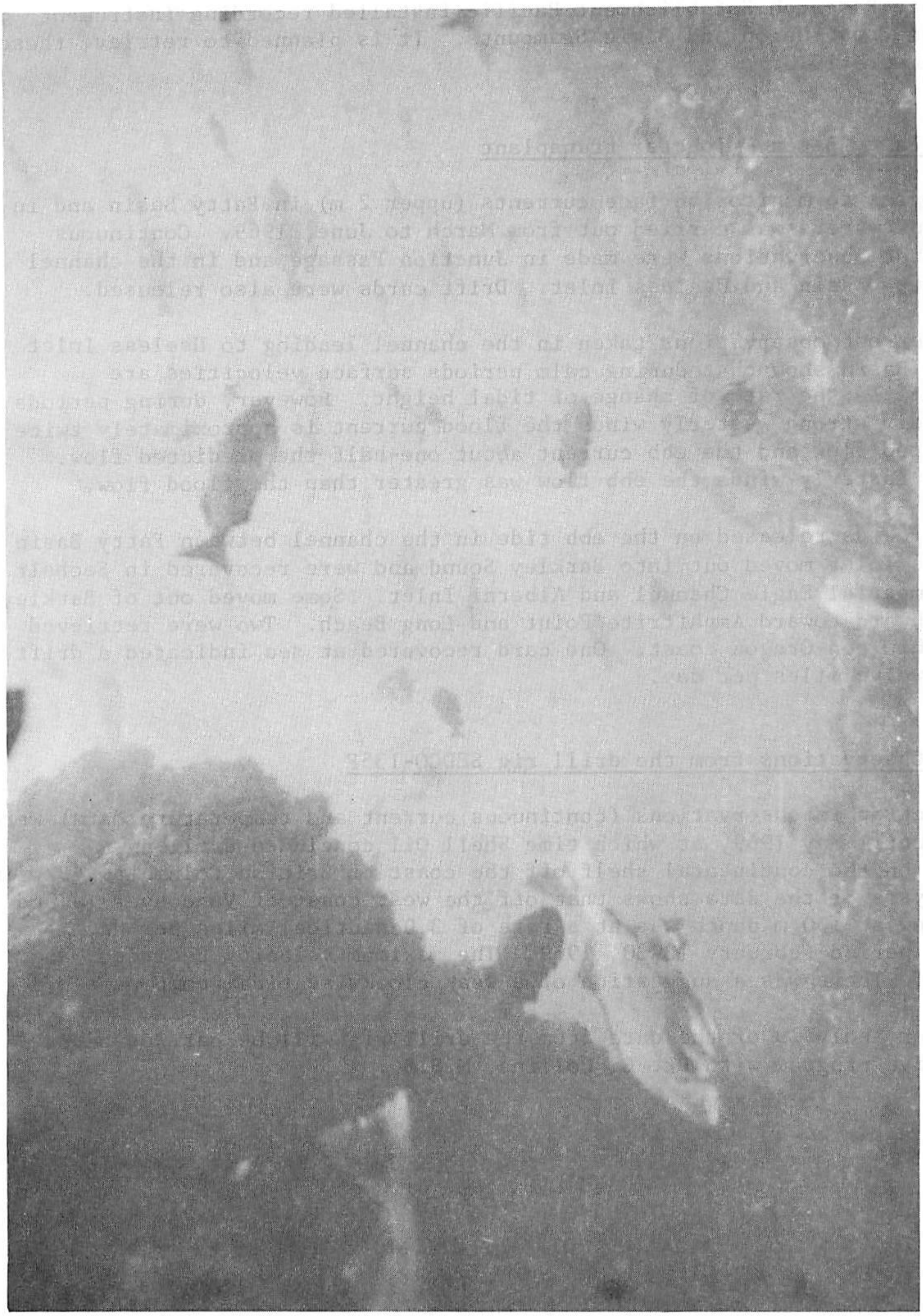


Fig. 16. A photograph showing the numerous fishes over Bowie Seamount.

The bottom organisms at 100 ft are also unique in that they are usually found in shallow intertidal coastal areas.

Defence Research Establishment Pacific installed recording instrument packages on Cobb, Union and Bowie Seamounts. It is planned to retrieve these in late summer, 1970.

(b) Fatty Basin - lobster transplant

A program to monitor surface currents (upper 2 m) in Fatty Basin and in the adjacent waters was carried out from March to June, 1969. Continuous current meter observations were made in Junction Passage and in the channel between Fatty Basin and Useless Inlet. Drift cards were also released.

The current observations taken in the channel leading to Useless Inlet from Fatty Basin show that during calm periods surface velocities are proportional .. the rate of change of tidal height. However, during periods of relatively strong westerly winds the flood current is approximately twice the predicted flow and the ebb current about one-half the predicted flow. During the easterly winds the ebb flow was greater than the flood flow.

Drift cards released on the ebb tide in the channel between Fatty Basin and Useless Inlet moved out into Barkley Sound and were recovered in Sechelt Channel, Imperial Eagle Channel and Alberni Inlet. Some moved out of Barkley Sound northward toward Amphitrite Point and Long Beach. Two were retrieved on the Washington-Oregon coast. One card recovered at sea indicated a drift of about twelve miles per day.

(c) Observations from the drill rig SEDCO-135F

Oceanographic observations (continuous current and temperature data) were continued until May 1969, at which time Shell Oil concluded drilling operations on the continental shelf off the coast of British Columbia. Preliminary analysis of the data shows that off the west coast of Vancouver Island the net flow at 100 m depth was at a rate of 3.0 nautical miles per day during the period February 12-20, 1969. The maximum velocity recorded was 1.08 knots. There was a suggestion of a weak clockwise tidal component.

Further analysis of the data from the drill rig will be carried out as a cooperative program with Dr. C. Collins, M.S.B.

7. DAILY SEAWATER OBSERVATIONS

H.J. Hollister

During 1969 surface sea temperature and salinity observations were made daily at 17 shore stations, the majority being located at Department of Transport lightstations. Starting in July, the collection of seawater samples for the laboratory analysis of salinity has been replaced at all but one station by the use of in situ measurement of seawater density by hydrometer. This changes the accuracy of the salinity data from 0.05‰ by analysis to 0.5‰ by hydrometer. It brings to an end, in a number of cases, 35 years of salinity determinations of seawater samples. Most of the stations were visited in the summer and fall months to deliver the hydrometer equipment and explain its use. The Canadian Coast Guard helicopter services were used extensively for these journeys; visits by land transportation were also involved.

Seawater temperatures at most stations were below normal during the winter months of January and February. This is a continuation of the cooler trend first noted in the December 1968 records. A period of near-normal temperatures followed in the spring and early summer months until June, when 8 of the stations reported above-normal temperatures. In August and September most stations had below-normal temperatures. Normal temperature conditions were generally prevalent in October and November, except at the 3 stations in Hecate Strait and the one at Cape St. James, all four of which reported above-normal temperatures. Salinities were most often near normal in the first 5 months of the year, with the exception of scattered occurrences of below-normal conditions at the stations on the Vancouver Island shores and in the Strait of Georgia during the 3-month period April to June.

At Langara Island, in the entrance to Dixon Entrance, monthly mean sea temperatures ranged from a minimum of 4.9 C in January and February to a maximum of 11.5 C in September. During the first 3 months of the year, temperatures were 1.1 C below normal. For the remaining 8 months the temperatures were never more than ±0.4 C from normal values. At the stations in the Hecate Strait region, sea temperatures ranged from a minimum of 4.4 C in February at Bonilla Island to a maximum of 12.9 C in July at McInnes Island. Temperatures were about 1.5 C below normal during the first 2 months, but in June they were 1.0 C above normal. A brief period of normal temperatures in July preceded a change to temperatures 0.7 C below normal in August and September. This cooler trend was reversed in October and November; at these times temperatures were 0.7 C above normal. Pine Island temperatures have a smaller seasonal range, from 6.1 C in February to only 9.9 C in July. Here also, winter temperatures were below normal; the spring and summer temperatures were in general normal, below-normal conditions being experienced only in August.

Along the exposed open coast from Cape St. James to Amphitrite Point, the average winter temperature of 6.1 C in February was 1.1 C below normal. The average summer temperature was 12.5 C. June temperatures were 1.0 C above normal. Below-normal temperatures occurred variously in August and September, followed by near-normal temperatures at Kains Island and Amphitrite Point during October and November. At Cape St. James during these latter 2 months, temperatures were above normal. At Race Rocks, in Juan de Fuca Strait, the sea temperatures ranged from a minimum of 6.4 C in February to a maximum of 10.5 C in August, just slightly higher than the temperatures recorded at Pine Island, at the extreme northern end of Vancouver Island. Significant below-normal temperatures were recorded at Race Rocks during the winter months January and February, and during the fall months of September and October. Summer temperatures at Sheringham Point, 15 miles further westward in the Strait, were 0.7 C higher than at Race Rocks.

In the Strait of Georgia, temperatures at the shore stations ranged from a minimum of 5.1 C in January at Sisters Island to a maximum of 18.2 C in July at Departure Bay. Temperatures averaging 1.2 C below normal were observed at stations in the central strait region during the first 4 months of the year. At Entrance Island the deficiency was as much as 1.6 C in January. Above-normal temperatures were reported at several stations for various months during the period May to July. Temperatures about 1.5 C below normal were observed in August and September in the central region, while at Cape Mudge in the northern region, below-normal conditions prevailed in July and September. Summer temperatures at Porlier Pass and Active Pass were 1 to 2 C lower than at Entrance Island.

Salinity data are available from most stations until May,and from a few until July. The patterns of monthly variations in salinity conditions change from region to region, but there was no clearcut, overall trend away from normal levels along the whole coast. There was only one occurrence of above-normal salinity, in January at Kains Island. Salinities for the most part were near normal, except for 1 or 2 months in the April to June period, when below-normal conditions were reported from stations along the coast of Vancouver Island south of Pine Island and in the Strait of Georgia. This was probably caused by excessive rainfall and river discharges that prevailed both on Vancouver Island and on the mainland coast during these 3 months.

8. POLLUTION STUDIES

(a) Pollution - oceanography - M. Waldichuk, J. Meikle

(i) Two 10-day cruises were made in August and September 1969. Oceanographic stations were taken in waters receiving pulp mill wastes along the east coast of Vancouver Island and in the northern passages and inlets in existing and potential pulp mill areas. The data are being processed for publication.

(ii) The study of the effect of winds on flushing Departure Bay, for which field work was carried out during July-August 1968, is being pursued in collaboration with Dr. T.S. Murty of DEMR, Ottawa. From early numerical analysis, there is agreement of theory and observations on upwelling by strong sustained westerly winds. The effect of offshore winds in such areas may prove to be an important factor in flushing out wastes received at the surface.

(b) Effects of water-borne solids - A.E. Werner

(i) Setting of wood particles: The apparatus for measuring "active" diameters was tested with 5 mm glass beads and 1/8 inch stainless steel balls and found to function satisfactorily. It was then applied to 15 kinds of wood particles, made of fir, cedar and hemlock woods in 5 particle sizes (63, 80, 125, 250 and 500 microns). Methods of operation: (1) the basic "fixed bed" method was refined to a "compressed bed" system in which (a) the initial column length is varied with the particle size in such a way that reasonable pressure differences are obtained at all flow rates used; (b) the water velocities are so adjusted that all measurements fall into the same flow range (laminar, intermediate); (c) the actual, not the nominal, column length is recorded together with flow and pressure difference. This method was particularly suitable for medium and large particles. (2) In the "expanded bed" method the expansion of an unconfined bed is measured as a function of water velocity. Experience showed that increasing the latter caused the upper bed limit to become increasingly diffuse even with repeatedly screened particles. Particles graded by elutriation gave slightly sharper boundaries. The "expanded bed" method was developed mainly for small particles. Data from both improved methods have been used to calculate "active" diameters. The calculations were based on formulae incorporating published empirical constants not necessarily applicable to wood. Consequently, the results bear little relation to the nominal particle sizes obtained by screening or, indeed, to one another. Therefore, these literature constants are now being re-evaluated for wood particles on the basis of our own data. Ultimately the "active" diameters will be related to the results of forthcoming experiments with the sedimentation trough.

Preliminary trials of the sedimentation trough were restricted to wood particles of intermediate to large particle sizes (125-500 microns). The particles behaved as expected in that even homogeneous-size groups settled in a pile not characterized by a Gaussian distribution. The following modifications were made to the equipment: (1) the middle section was lengthened from 1 m to 3 m; (2) larger flow meters were installed; (3) a larger reservoir was inserted between circulating pump and trough; (4) the return flow system was enlarged; (5) the orifices of the weirs were enlarged; (6) the particle feed system was moved forward; (7) drains and feed inlets were provided. These modifications extend the capacity of the trough to handle smaller particles and to make more accurate measurements.

(ii) Microbiology: Bacteriological surface and bottom samples were taken at 12 stations off Port Alice (2.VI.69). The organisms in these samples were subjected to standard bacteriological techniques in order to culture and isolate cellulose-degrading microbes. The surface water of all stations was free from cellulo-clastic organisms and so were 2-3 of the bottom samples. The latter came from marginal stations (at which gas had not been observed in 1966). All other bottom samples contained an abundance of cellulose degraders.

All surface and about half the bottom samples contained Gram-positive organisms although there were many more Gram-negative vilvios, rods, tetrads and thread-like aggregates. Malodoriferous gas was produced in nearly all cases, suggesting not only H_2S but also skatole. The attack on cellulose (Whatman filter paper #1) consisted in perforating the paper wherever colonies had settled, forming a viscous suspension of the decaying fibres. The cellulose degraders grew at 15 C but not at 25 C and in anaerobic conditions only. The accompanying organisms were not so selective.

Similar samples were taken at 12 stations off Port Alberni in October. In addition to treating them like those from Port Alice, they are also being tested for ligno-clastic organisms. Fir, cedar and hemlock woods are used. Growth and gas production was observed in nearly all samples, but attack on wood and cellulose is not yet apparent. This is normal in view of the 134-day incubation period which the Port Alice samples required.

(iii) Bio-assay of wood-extractives: The toxicity to *Arternia salina* was tested of seawater extracts of fir, cedar and hemlock woods. Animals exposed at 23 C for 24 hrs to various concentrations of these extracts were so highly resistant as to render this species unsuitable as a test-organism. Search for a test-organism continues.

(iv) Leaching rates: The installation was modified and the water handling and filtration system enlarged. The first few batches of leaching data were produced.

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