JOINT COMMITTEE ON OCEANOGRAPHY

PACIFIC OCEANOGRAPHIC GROUP

ANNUAL REPORT, 1955-56

Copy 1

Pacific Oceanographic Group
Nanaimo, B.C.
March 31, 1956

CANADIAN JOINT COMMITTEE ON OCEANOGRAPHY

PACIFIC OCEANOGRAPHIC GROUP

Nanaimo, B. C.

ANNUAL REPORT 1955-56

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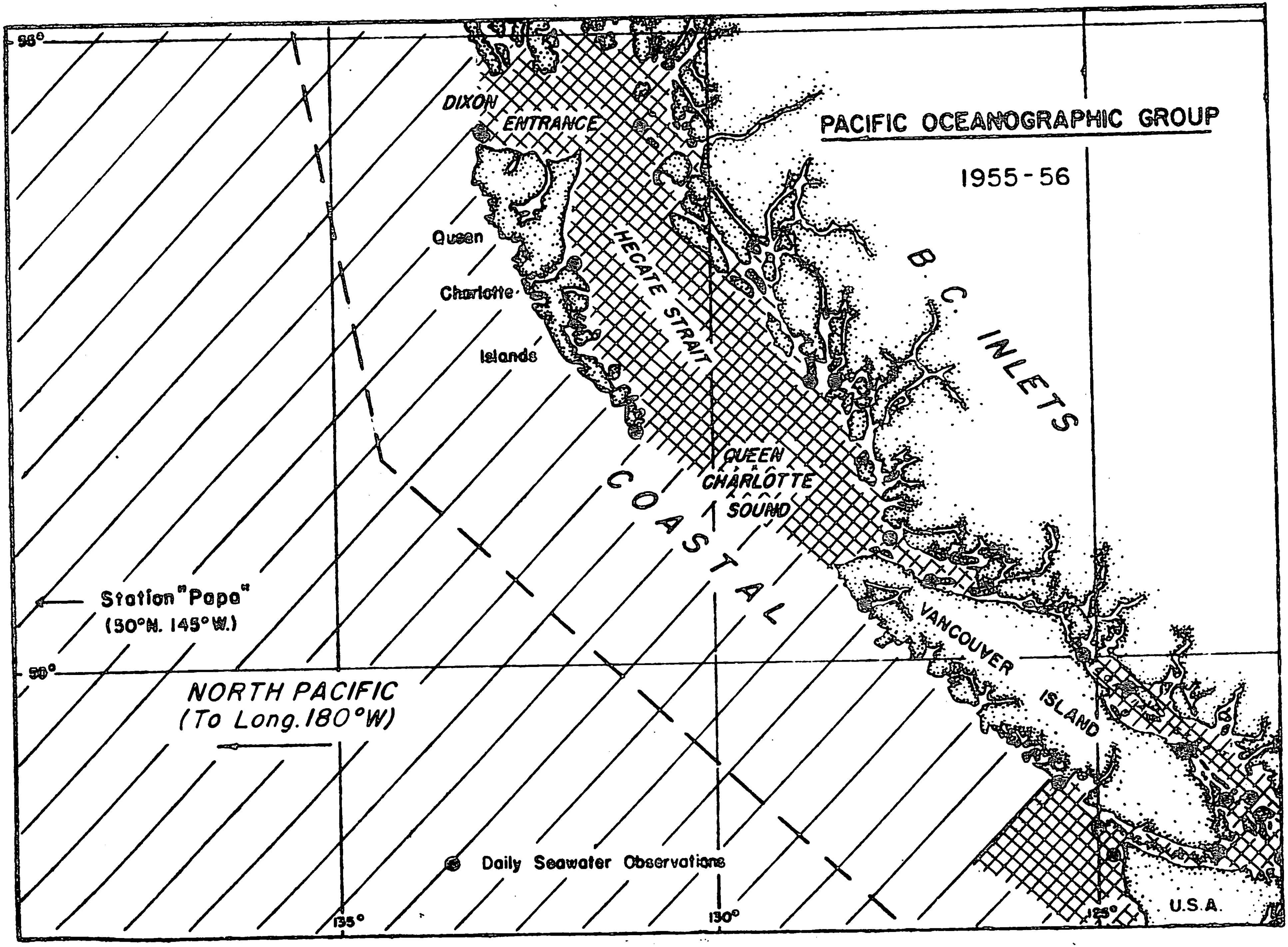
March 31, 1956.



PACIFIC OCEANOGRAPHIC GROUP
1955-56
B.C. INLETS
COASTAL
NORTH PACIFIC
(To Long. 180°W)
DIXON ENTRANCE
HECATE STRAIT
QUEEN CHARLOTTE SOUND
Queen Charlotte Islands
VANCOUVER ISLAND
U.S.A.
Station "Papa"
(50°N. 145°W.)
Daily Seawater Observations
135°
130°
125°
50°

Appendix II

ANNUAL REPORT

PACIFIC OCEANOGRAPHIC GROUP

Introduction

1. The Pacific Oceanographic Group under the Canadian Joint Committee on Oceanography is responsible for oceanographic activities in the Pacific approaches to Canada. With the advent of an Arctic Group based on H.M.C.S. "Labrador", this Group has withdrawn from active research in the Western Arctic.

2. The program has been designed primarily to meet the immediate and long-term requirements of the Fisheries Research Board of Canada and the Royal Canadian Navy. The Navy has provided two research vessels, H.M.C.S. "Cedarwood" and C.N.A.V. "Ehkoli" which are used jointly by this Group and the Pacific Naval Laboratory. Additional service vessels have been allocated from time to time as the work demanded. The Fisheries Research Board provides the ordinary expenses, personnel, laboratory space and scientific equipment.

3. This Group undertakes observation of the properties of the water. However the data required for oceanographic study also includes depth, bottom materials, shore line, tides, land drainage, meteorology, and the oceanography of contiguous seas. All these data are gathered by other agencies, domestic and foreign. Hence the Group maintains a close liaison at the working level with the hydrographic, hydrological and meteorological agencies working in the northeast Pacific. The best results have been brought about by data exchange and cooperative observation and use of facilities.

Staff

4. During the past year the staff of the Group consisted of:

J. P. Tully,	Oceanographer-in-Charge
N. J. Campbell,	Associate Oceanographer (transferred to A.O.G., March 31)
F. G. Barber,	Associate Oceanographer
A. J. Dodimead,	Associate Oceanographer
R. A. Pollard,	Assistant Oceanographer (to February 14)
S. Tabata,	Assistant Oceanographer
R. W. Trites,	Junior Oceanographer (on educational leave to May 31. Returned to A.O.G. June 1)
N. P. Fofonoff,	Assistant Oceanographer (Term to April 30)
G. L. Pickard,	Associate Oceanographer (Seasonal May 15 - July 31)
M. Kirsch,	Assistant Oceanographer (Seasonal May 1 - August 31)
H. J. Hollister,	Technician, Gr. 3
R. H. Herlinveaux,	Technician, Gr. 2
A. W. Groll,	Technician, Gr. 2 (to November 15)
L. D. B. Terhune,	Technician, Gr. 2 (Term from April 1)
L. H. McCracken,	Technician, Gr. 1
J. A. Stickland,	Assistant Technician, Gr. 3
M. A. Smith (Mrs.),	Assistant Technician, Gr. 2
B. M. Berisford (Miss),	Stenographer, Gr. 3
E. B. Bennett,	Seasonal Investigator (May 1 - September 15)

C. Sauer,	Seasonal Investigator (May 30 - September 15)
A. E. Filmer,	Seasonal Investigator (June 15 - September 2)
L. M. McKenzie,	Seasonal Investigator (June 15 - September 15) Assistant Technician, Gr. 1 (September 16 - October 31)
Lt. D. A. Still (LTJG) U.S.N.	Volunteer Investigator (from U.S. Naval Postgraduate School, Monterey, California) (June 27 - August 6)

General Program - 1955

5. The general program has been centered around the provision of an atlas of oceanographic data in all our Pacific Coast regions. Daily observations of surface sea water temperature and salinity are made at a number of stations to provide marine climatological records. Synoptic surveys of limited areas are undertaken to identify the water masses, their area, depth, and movements. The synoptic surveys define the meaning and domain of the daily sea water observations. These may then be used as indices of the occurrence and duration of the oceanographic states.

6. A pattern of study has evolved from experience. An area is defined and the possible information that may be required is assessed. Observations are undertaken using the accumulated experience of previous studies as guides. These data are reduced to usable values and published (mimeographed) in Data Records. Then study of the data is undertaken to produce general reports describing the major oceanographic features and processes. Specific information for fisheries, naval, industrial or municipal purposes

are then taken from the general reports, the data, or may require additional data. Each step of the process is documented as it is made. This ensures availability of the data and research.

7. This program is well advanced. Most of the coastal seaways have been surveyed. The waters over the continental shelf remain to be observed. The offshore oceanic waters have had preliminary examination. Programs for systematic observation have been proposed (Swiftsure, North Pacific) which will probably be implemented in the near future. The use of hydraulic models to solve oceanographic mechanisms and interpret data has been undertaken.

8. During the year there has been a transition of effort from the gathering of data to the study of data. Study of the Hecate, Strait of Georgia, and Juan de Fuca data is going forward, some conclusions have been published, and many others are in sight. Serious study of the daily sea water data has been initiated in conjunction with these, and it is already evident that they justify the claims and effort made for them.

9. This is a happy situation for the research staff; to have adequate data and leisure to develop it into sound scientific reports. It is hoped that this situation may continue through next year to its warranted conclusion.

<u>Particular Program</u>

10. Daily Sea Water Observations: Daily observations of sea water temperature and salinity are being made at seventeen positions (mostly lightstations) along the British Columbia coast. This program started with one station (Departure Bay)

in 1914. Since then stations have been added as the need became apparent, or dropped when their usefulness ceased.

11. This is the most comprehensive time series of observations on the Pacific Ocean and is comparable in scope and application to the daily meteorological observations. It was undertaken to provide a climatological record of coastal waters as background information for oceanographic and fisheries research. It is developing into the principal criteria of oceanographic processes and events.

12. Mr. H. J. Hollister manages this program of observations, and the data records. The salinity of the sea water samples is determined in the titrations laboratory under Mr. L. H. McCracken, and the data are processed and tabulated by Mrs. M. A. Smith.

13. Mr. Hollister has published a series of articles describing the location and operation of the observing stations. Each year he presents a climatological review of the past year's data and compares it with previous years. He also prepares a weekly summary of sea water temperatures from four locations, and a comparison with corresponding data from previous years. This is aired over CBU on the Fishermen's Broadcast every Wednesday morning.

14. Development of the data began a few years ago when Dr. G. L. Pickard and Mr. D. C. McLeod defined the mean annual cycles of temperature and salinity and the principal controlling factors. They showed that there were three types of coastal oceanographic regions, and that each observing station represented a domain within one or other of these.

15. At the present time, Mr. S. Tabata is studying the data from five stations in the Hecate region. He has devised a statistical method of classifying the data to define normal and abnormal states. The method is readily applicable to correlation of oceanographic factors to the fisheries where adequate data exist. He is also examining the contributions of solar radiation, cloud cover, effective back radiation, conduction, and evaporation to the temperature cycle; and the contributions of precipitation, land drainage, and advection of ocean water to the salinity cycle.

16. Dr. J. P. Tully is studying data from three stations in the Strait of Georgia. In addition to the statistical analyses, he is correlating salinity to the Fraser River discharge and is giving particular attention to the phenomena of diurnal and seasonal heating and cooling, and heat exchange with the atmosphere.

17. Mr. R. H. Herlinveaux is studying data from Face Rocks in the Strait of Juan de Fuca where he has revealed a correlation of the daily surface sea water with data from synoptic surveys.

18. Weathership "Papa": The Department of Transport is operating the Weathership on Station "Papa" (Latitude 50° N., Longitude 145° W.). Two ships occupy the station for alternate periods of forty-two days each, observing the weather continuously. Each ship has been equipped with a winch and bathythermograph, and the ships' companies make observations of temperature, from the surface to 450 feet depth, every two hours enroute to and from the station (weather permitting) and twice daily on station. This provides a mid-ocean time series of weather and ocean temperatures.

19. Mr. Hollister has been in charge of this program of oceanographic observations since its inception in July, 1952. The data are regularly processed, bathythermograms photographed, and surface temperatures are reported annually in the Manuscript Series, "Observations of Seawater Temperature and Salinity on the Pacific Coast of Canada". He is now preparing a climatic review of the data, illustrating the seasonal cycle of temperature structure and its variations through the years of observation.

20. Station "Papa" is situated close to the region where the North Pacific Drift Current divides, part turning north into the Gulf of Alaska and part turning south to form the California Current. It is in the region of maximum horizontal temperature gradient as shown by the NorPac survey. Hence any changes in the Drift Current should be indicated by marked changes of temperature levels. Thus the station is an ideal monitor of the ocean waters moving towards the Canadian Coast. It is evident that analyses of these data in conjunction with the NorPac survey should provide a critical assessment of oceanic conditions in this region of the North Pacific which is most important to Canadian interests. Proposals have been made to augment this program and to provide for study of the data.

21. Hecate Project: The Hecate Project undertakes to describe the water masses, properties of the water, and the currents throughout the year in Queen Charlotte Sound, Hecate Strait and Dixon Entrance. A year's series of seven bi-monthly oceanographic surveys on a planned-grid pattern were completed in June. These encompassed all parts of the area in all seasons. Temperature,

salinity and dissolved oxygen were observed at standard depths from surface to bottom on all surveys. During four expeditions, the tidal and non-tidal currents were observed every half-hour through fifty hours, at standard depths. These data have been published in three manuscript Data Records and are being studied by Mr. F. G. Barber.

22. Hecate Model: Currents and water movements in the area are primarily due to wind and tide and density gradients. It became evident in the early analysis of current observations that the tidal currents were complex. They could not be simply related to the tides tabulated for the region. Observations thus far have been inadequate to define the characteristic features of tidal circulation.

23. In view of the difficulties of obtaining reliable current data, and the prohibitive expense of developing a network of current stations for the entire region, alternatives to extensive current surveys were considered. Dr. N. P. Fofonoff analysed this problem and envisioned a hydraulic model to solve the tidal circulation. In addition, the model provides a means of viewing all the features at once and watching the sequence of events. This will certainly facilitate appreciation of the oceanography and interpretation of the data.

24. Construction of the model base was begun early in the year and it is hoped to complete the work under Mr. L. D. B. Terhune during 1956, and to make the observations during 1957.

25. NorPac Project: The NorPac Project was an international joint synoptic oceanographic survey over the whole Pacific Ocean north of the Tropic of Cancer and was carried out during August, 1955. There was one Canadian, seven United States and ten Japanese ships, each surveying a predetermined part of the area.

26. Such a survey has long been needed to determine the properties of the water, the currents and the biological productivity of this area, and to provide the background knowledge for the studies of fisheries problems.

27. To date the data records of all the agencies have been exchanged, the preliminary work has been reviewed and plans are now underway to publish an oceanographic atlas, which will include all the data and charts showing the distribution and properties of the water of interest to fisheries and to oceanography. The date of publication has been set for March 1, 1957.

28. The magnitude of this project clearly demonstrates what can be achieved by international cooperation in oceanographic research. It is hoped that further studies of this kind can be carried out.

29. Preliminary research already has demonstrated the effectiveness of the project. It clearly shows the need for information in the whole oceanic system if any of the parts are to be fully understood. This has shown to be particularly true in our own area.

Mr. A. J. Dodimead's analyses of the data from the surveys and exploratory fishing show that the Pacific salmon occur only in the region where the surface waters have lower salinities than are normally encountered in oceanic waters. It appears that their distribution is not related to temperature.

30. Strait of Georgia Project: Dr. M. Waldichuk has completed his study of the data, from the synoptic surveys of 1949 through 1951, under the title, "Physical Oceanography of the Strait of Georgia". On the basis of temperature, salinity and current observations, he discussed the circulation, mechanism, and flushing characteristics of the region.

31. Dr. Tully is still working on the treatise "Properties of the Water in the Strait of Georgia" based on data collected prior to World War II, and the daily sea water observations. This study gives particular attention to the distribution of physical and chemical properties in space and time, and to controlling factors. The cycles of Fraser River discharge, insolation, the consequent structures, their relations and probability of occurrence are discussed.

32. These two researches are complementary and when combined with the Data Records form a comprehensive study of this region. It is proposed that the two lengthy papers be published together in a single volume.

33. Juan de Fuca Project: Synoptic surveys and comprehensive current measurements were made in Juan de Fuca Strait during 1951 and 1952. Mr. Herlinveaux has solved the tidal mechanisms and devised a method for predicting the tidal currents in all parts of the area from information in the Tide Tables.

34. As time from other duties allows, he is studying the properties of the water. He has derived the annual cycles of

temperature and salinity and their controlling factors. He has found that temperature bears a simple linear relation to salinity in all parts of the region throughout the year. The cycle of variation is dependent on coastal drainage, insolation and occurence of coastal upwelling. The material is being arranged in two studies; one dealing with the time sequence of events at representative locations, and the other dealing with the differences from one part to another of the region.

35. Data in the approaches to Juan de Fuca Strait were collected in 1936 through 1938. These have been processed and partially analysed by Dr. Tully. These studies should be continued, utilizing the daily sea water observations at Swiftsure Lightship.

36. British Columbia Inlets Project: During the past few years, Dr. Pickard has made observations of the characteristics of the large inlets on the British Columbia coast. He has been devoting his available time to study of these data.
He has made observations of depth, temperature, salinity, oxygen and bottom materials for most (29) of the major inlets. There are observations during two to five years in six of the larger inlets.

37. From a study of the heat budget he has developed a technique for estimating the mean seaward flow out of the inlets (Trites and Pickard) and this also yields an estimate of runoff when the salinity is known. This has been applied in a number of cases.

38. He has made observations of internal waves in the upper layers (0 - 80 feet) and in mid-depth (100 - 400 feet) in Bute

and Knight Inlets, and measurements of current profiles from surface to 1,000 feet in the southern inlets. He has observed that internal waves are large in the inlets and that surge currents as great as one knot occur in the deep waters.

39. He has also made an examination of bottom currents across the central part of Georgia Strait. Here he found reversing tidal currents of the order of 0.2 to 0.6 knots. The corresponding surface currents were of the order of one knot. It was observed that the tidal currents were strongest on the right in accord with the Coriolis force; the north-flowing flood is strongest on the mainland side, and the south-flowing ebb on the Vancouver Island side.

40. Chemistry: Dr. M. Kirsch has studied the ionic ratios in the brackish waters near several estuaries. He found that the magnesium content was higher and the potassium content lower in these regions than in the normally saline (30 °/₀₀) sea water. He attributes the magnesium to the inflowing fresh water. He suggests that potassium is probably adsorbed on the silt.

41. He also found that the alkalinity of these waters was high and that this effect persisted for some distance from the stream. He suggests that this property may be used to trace the movements of water from an individual river.

42. Hydraulics of Salmon Spawning Gravels: A study of the hydraulics of flow through gravel in salmon spawning redds, in conjunction with the Salmon Investigation of the Biological Station, Nanaimo, B. C., was undertaken and the first phase was completed by Mr. R. A. Pollard in 1954. This involved the design

and calibration of equipment with which fisheries biologists could measure the oxygen content and flow of water through the redds, to determine the probability of survival of the eggs. A model spawning bed was established in the Model Laboratory where extensive studies of the flow through uniform and random gravels were made. The conclusions have been reported and implemented in the assessment of spawning areas in British Columbia and in the United States.

43. It has become apparent that modifications of apparatus, extension of the limits of calibration, and measurements of permeability of clutches of salmon roe, and estimation of waste products in the groundwater are also required. Mr. Terhune is carrying out this second phase of the work in cooperation with Mr. W. P. Wickett. It will lead to a further publication on this subject.

44. A number of technical services are required to support the research efforts.

45. Mr. McCracken, with assistance from sea technicians, determines the salinity of all sea water samples from the expeditions and daily observations. During the past year 20,000 titrations have been made. He also prepares standard solutions for use at sea, assembles and calibrates apparatus, and maintains a general laboratory service.

46. Mrs. Smith, and sea technicians when available, carry out routine computations involved in processing data, under direction of the scientist in charge of the project (Hecate, NorPac, etc.) on which they are working. This includes

instrument corrections, conversion of units, dynamic height calculations, and checking. The oceanographic data from each project are published in a manuscript series, "Physical and Chemical Data Records" which are prepared by Mrs. Smith. She also makes photographic enlargements of the bathythermograms, transcribes the auxiliary data on the reverse, and catalogues the cards for ready reference.

47. Mr. Herlinveaux services, stores, and maintains all sea equipment. In addition, he calibrates bathythermographs and prepares standard grids for the Pacific Naval Laboratory, Royal Canadian Navy, and the Institute of Oceanography at the University of British Columbia.

48. All data are catalogued by Mr. Hollister and preserved for use in a fireproof vault. He also maintains a "ready use" library of oceanographic reprints.

49. Mr. Hollister manages procurement and supplies. Miss B. M. Berisford handles all secretarial duties, filing and typing. Dr. Tully directs all research and administration.

<u>Liaison</u>

50. Biological Station, Nanaimo, B. C.: There is close contact at the working level between all members of this Group and the biological staff. Equipment and service has been provided for bathythermograph observations in the Young Salmon Program, Mid-Water Trawl Project, and Lake Studies. Plankton has been collected. Oceanographic equipment has been loaned to the Pollution Studies and Juvenile Herring Surveys. Salinity determinations have been made on samples collected by these groups

and bathythermogram prints have been provided. Arrangements have been made for the use of C.N.A.V. "Ehkoli" for several Pollution surveys. Joint studies have been undertaken on salmon spawning gravels and suspected shipworm infestation in the Fraser River Estuary. Daily sea water observations are being made at two stations at the request of the Herring and Groundfish Investigations.

51. Real assistance has been received from the Biological Station in the design and furtherance of research, facilities, direction, and administration. The assistance of Mr. M. Pirart and facilities of the Electronics Laboratory on the Hecate Model Project have been made available; also the art service of Mr. G. D. G. Denbigh in preparation of conceptions of the Hecate Model. All these are appreciated.

52. Pacific Naval Laboratory: There is close contact at the level of work between all members of both Groups. The resources, particularly the ships (C.N.A.V. "Ehkoli" and H.M.C.S. "Cedarwood") are pooled so that either Group may use either or both ships. The Pacific Oceanographic Group provides all oceanographic information to the Pacific Naval Laboratory including an atlas and oceanographic monitoring of P.N.L. operations. The Pacific Naval Laboratory manages the ships, provides all liaisons with the Navy, and provides base facilities in H.M.C. Dockyard.

53. Recently the Pacific Naval Laboratory built and installed equipment for bathythermograph calibration which is operated by the Pacific Oceanographic Group. The Pacific Naval Laboratory

is providing specialized machine design and shop service in the construction of bathythermograph winches for the Weathership Program, and alterations to the deep-recording current meter (bathyrheograph). They also undertook management, and bore the expense of the alterations to H.M.C.S. "Ste. Therese" for the recent NorPac Operation. Without this generous co-operation, it would be impossible for this Group to have operated successfully.

54. Hydrographic Service: Close liaison has been maintained with the survey and tidal work of the Service. C.G.S. "Wm. J. Stewart" made regular oceanographic observations, and a joint tidal current measuring project was carried out with C.G.M.V. "Parry" in the Hecate region. Copies of all current measurements are provided to the Tidal Branch.

55. In this liaison, it has been made clear that the Hydrographic Service is concerned with the prediction of tidal currents for shipping and their conclusions are published on the charts and in the Tide Tables. The Pacific Oceanographic Group is concerned with tidal circulation and transport of water at all depths. The collection of data is often similar but the use and interpretation is different.

56. Meteorological Service: The Port Meteorological Officer at Vancouver collects sea water temperature data from several coastal ships and refers them to the Pacific Oceanographic Group. Copies of the original weather data from meteorological stations at or near the daily sea water sampling stations are provided by Gonzales Observatory in Victoria. Barometric charts and specific data are provided on request from these

agents and from the Air Services Weather Bureau at Sea Island Airport, Vancouver. The Head Office of the Meteorological Service in Toronto has provided a complete set of the Canadian weather records dating from 1889, in addition to copies of all publications and microfilm copies of the ocean weather observations at Station "Papa".

57. Department of Transport: Most of the daily sea water observations are made by lightkeepers of the Department of Transport. For this service they are paid on honorarium. The District Marine Agents at Victoria and Prince Rupert provide liaison with these observers, and arrange transport of most of the samples and supplies in Department of Transport ships. The Agent at Victoria also provides liaison with the ships on Ocean Weather Station "Papa". Their assistance in expediting shipments of equipment, and bathythermograph supplies to the ships is invaluable. The efforts of the officers and men of the ships in maintaining the continuity of the bathythermograph observations is worthy of the highest praise.

58. The Telecommunications Division of the Air Services Branch transmit the weekly reports of daily water temperature observations that are used for the weekly broadcast of sea water temperatures.

59. Department of Public Works: Recently the Department was concerned with the possibility of Bankia infestation in the Steveston Harbour Basin in the Fraser River. Mr. Tabata studied the oceanography of the situation, and Mr. R. J. Le-Brasseur (of the Biological Station, Nanaimo, B. C.) studied

the biology. A report including their recommendations is appended. From time to time oceanographic data are provided from the files as requested by the Department.

60. Institute of Oceanography: It is recognized that the Institute is the primary source of trained oceanographers in Canada and every effort is made to ensure its survival and healthy growth. Equipment is loaned, and seminars on Oceanographic research are given. Employment has been provided for the professors so that they may be able to continue their researches during the summer recess. Employment is also provided for students. This provides much needed assistance for the Pacific Oceanographic Group, and is a method of recruiting oceanographers.

61. The Institute reciprocates by assigning research problems in our data which has materailly helped research production. Examples of such work are McLeod's thesis on daily sea water observations, Trites' thesis on Chatham Sound, and Campbell's thesis on Burrard Inlet.

62. Canadian Broadcasting Corporation: A weekly review of sea water temperatures, and a comparison with previous years is aired every Wednesday morning (7:00 a.m.) from the Vancouver Station, CBU, on the Fishermen's Broadcast. This service was inaugurated March 16, 1955.

63. Several recorded interviews have been given, describing the Hecate and NorPac Projects for broadcast on the Canada Series.

64. Public Service: Requests for information are continually being received from public and commercial bodies. These are met wherever possible from data in the files, or by advice on techniques of observation and interpretation. In the past year, the British Columbia Electric Company has required knowledge of bottom temperatures and currents, chemical companies have consulted on suitable sites for recovery plants. The City of Vancouver has sought information on sewage dispersion from particular outfalls. A Vancouver citizens' committee has asked for information regarding suitable locations for airports. The number of requests and range of interest for oceanographic information is steadily increasing.

Publications

65. The following papers have been published during the year (since November 15, 1954) or are presently in press:-

Barber, F. G.

Water Masses in Queen Charlotte Strait. Fish. Res. Bd. Canada, Prog. Rept. Pac., #100, 6-7. October, 1954.

Seasonal Temperature and Salinity Variations in Queen Charlotte Strait, B.C. Fish. Res. Bd. Canada, Prog. Rept. Pac., #105, 14-15, February, 1956.

and S. Tabata.

The Hecate Oceanographic Project. Fish. Res. Bd. Canada, Prog. Rept. Pac., #101, 20-22. December, 1954.

and A. W. Groll.

Current Observations in Hecate Strait. Fish. Res. Bd. Canada, Prog. Rept. Pac., #103, 23-25, July, 1955.

Doe, L. A. E.

Offshore Waters of the Canadian Pacific Coast. J. Fish. Res. Bd. Canada, 12 (1) 1-34. 1955.

Dodimead, A. J.

Project NorPac. Fish. Res. Bd. Canada, Prog. Rept. Pac., #105, 16-18, February, 1956.

Herlinveaux, R. H.

Tidal Currents in Juan de Fuca Strait. J. Fish. Res. Bd. Canada, 11 (6) 799-815. 1954.

Kirsch, M.

Ionic Ratios of the Major Components in River-Diluted Sea Water in Bute and Knight Inlets, British Columbia. J. Fish. Res. Bd. Canada. In Press.

LaCroix, G. W. and J. P. Tully.

The Anomaly of Mean Sea Level in Seymour Narrows, B. C. J. Fish. Res. Bd. Canada, 11 (6) 853-883. 1954.

McCracken, L. H.

The Salinity of Sea Water. Fish. Res. Bd. Canada, Prog. Rept. Pac., #102, 24-26. March, 1955.

A Simple Technique for Sealing Sea Water Samples. Journ. Mar. Res. In Press.

Pickard, G. L.

British Columbia Inlets. Trans. Amer. Geophys. Union, 36, 5, 897-901. October, 1955.

Surface and Bottom Currents in the Strait of Georgia. J. Fish. Res. Bd. Canada. In Press.

Pollard, R. A.

Measuring Seepage Through Salmon Spawning Gravel. J. Fish. Res. Bd. Canada, 12 (5) 706-741. 1955.

Tabata, S.

Oceanography of British Columbia Mainland Inlets. V. Salinity and Temperature of Waters of Bute Inlet. Fish. Res. Bd. Canada, Prog. Rept. Pac., #100, 8-11. October, 1954.

Oceanographic Conditions in Steveston Harbour During Normal Discharge of Fraser River. Fish. Res. Bd. Canada, Prog. Rept. Pac., #104, 26-29. November, 1955.

A Technique for Classifying Daily Seawater Observations of Temperature and Salinity. Trans. Amer. Geophys. Union. In Press.

Sea Water Intrusion in Steveston Cannery Basin. Fish. Res. Bd. Canada, Prog. Rept. Pac. In Press.

and A. W. Groll.

Effect of Ship's Roll Upon the Measurements Obtained by the Ekman Current Meter and Upon Its Behaviour. Trans. Amer. Geophys. Union. In Press.

Trites, R. W.

Oceanography of Chatham Sound. J. Fish. Res. Bd. Canada. In Press.

Tully, J. P.

Conditions for Troll Fishing. Fish. Res. Bd. Canada, Prog. Rept. Pac., #101, 12-16. December, 1954.

Tully, J. P.

Oceanographic Vessel's Ordeal. Fish. Trade News, 7, 7, 12-13. January, 1955.

Oceanography Along the Canadian Pacific Coast. Inter. North Pac. Fish. Comm., Bull. No. 1, 130-138. 1955.

Pollution Research in Alberni Inlet. Trans. Seventh B. C. Natural Resources Conference, 296-300. February, 1954.

Recent Advances in Oceanography. Amer. Peoples' Encyclopedia, Annual Supplement, Chicago, 799. 1955.

Recent Advances in Marine Biology. Amer. Peoples' Encyclopedia, Annual Supplement, Chicago, 682. 1955.

and A. J. Dodimead.

Salmon Water. Fish. Res. Bd. Canada, Prog. Rept. Pac. In Press.

Manuscript Reports

66. The following manuscript reports have been distributed during the past year:-

Anonymous.

Observations of Seawater Temperature and Salinity on the Pacific Coast of Canada, Vol. XIV. 1954. July 1, 1955.

Physical and Chemical Data Record, Hecate Project, 1954. January 15, 1955.

Data Record. Current Measurements, Hecate Project, 1954. March 1, 1955.

Anonymous.

Physical and Chemical Data Record, Juan de Fuca Strait Project, 1951-52. With Appendix I, Current Measurements. April 30, 1955.

Physical and Chemical Data Record, Hecate Project. With Appendix I, Current Observations, 1955. August 15, 1955.

Physical, Chemical and Plankton Data Record, Project NorPac, July 26 - September 1, 1955. February 1, 1956.

Saur, J. F. T., J. P. Tully and E. C. LaFond.

Oceanographic Cruise to the Bering and Chukchi Seas, Summer, 1949.

IV. Physical Oceanographic Studies. April 1, 1955.

Tabata, S.

The Problem of Sea Water Intrusion in Steveston Cannery Channel. October 15, 1954.

Studies in Steveston Harbour Basin.

Part 1. Sea Water Intrusion into the Steveston Harbour Basin. February 15, 1955.

<u>Summary Reports</u>

67. The following summary reports are attached:-

(a) Daily Seawater Observations, 1955. H. J. Hollister.

(b) Ocean Weather Station "Papa" Bathythermograph Observations. H. J. Hollister.

(c) Classification of Daily Sea Water Data. S. Tabata.

(d) Hecate Project - Water Masses in the Hecate Region. F. G. Barber.

(e) Heat Budget Studies. S. Tabata

(f) Hecate Project - Current Observations. F. G. Barber.

(g) Hecate Tidal Model. N. P. Fofonoff.

(h) Project NorPac. A. J. Dodimead.

(i) Salmon Water. A. J. Dodimead.

(j) Strait of Georgia. J. P. Tully.

(k) Juan de Fuca Strait. R. H. Herlinveaux.

(l) Hydraulics of Salmon Spawning Gravels. L. D. B. Terhune.

(m) Sea Water Intrusion in Steveston Cannery Basin. S. Tabata.

(n) Sea Water Analyses Laboratory. L. H. McCracken.

(o) Data Records. H. J. Hollister.

(p) Bathythermograph Calibration. R. H. Herlinveaux.

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Nanaimo, B.C.
March 31, 1956.

Daily Seawater Observations, 1955

General: There are seventeen locations on the British Columbia Coast at which a daily water temperature and seawater sample were obtained during 1955.

At eleven of the locations shown in the accompanying Table, the records extend for periods varying from forty-one years (Departure Bay) to fourteen years (Race Rocks).

Station	Commenced Observations	Station	Commenced Observations
Departure Bay (Biological Stn.)	September, 1914	Entrance Island	November, 1936
Cape St. James	July, 1934	Pine Island	January, 1937
Amphitrite Point	August, 1934	Ivory Island	July, 1937
Kains Island	January, 1935	Triple Island	November, 1939
Cape Mudge	November, 1936	Langara Island	March, 1940
		Race Rocks	May, 1941

Observations at Ivory Island lightstation in Milbanke Sound were terminated in December, 1955. Daily seawater observations in this region are now being made from McInnes Island lightstation, which commenced these observations in August, 1954.

At the six other locations:- East Point lightstation, Beaver Point wharf, Texada Mines wharf, Pulteney Point lightstation, McInnes Island lightstation, and Sandspit wharf, observations have been made for periods ranging from thirty months(Texada Mines) to sixteen months (Pulteney Point and McInnes Island).

A daily seawater observations program is also conducted by personnel of the United States Coast Guard on the ships that occupy the Swiftsure and Umatilla lightship positions in the approaches to the Strait of Juan de Fuca. These include twice-daily bathythermograph lowerings (200 feet). The observations at Swiftsure were commenced in July, 1954; at Umatilla in July, 1955.

Daily water temperatures are observed by Department of Fisheries personnel at the New Westminster wharf, and the records are continuous since 1927.

In March, 1955 the four observing stations of Amphitrite Point, Entrance Island, McInnes Island and Triple Island commenced sending weekly reports of daily seawater temperatures to Nanaimo through the wireless facilities of the Department of Transport. These reports, along with a summarizing analysis, are sent to the Canadian Broadcasting Corporation Station CBU in Vancouver for presentation on the regular Wednesday morning "Broadcast for Fishermen".

Seawater Temperatures: The monthly mean surface seawater temperatures on the British Columbia Coast during 1955 were generally colder than the averages for the past ten-year period (1945-1954), with the exceptions of the months of January and February. At each station these two months were warmer than the 10-year average. January always showed the largest departure from average, the greatest departure being at Langara where the monthly mean temperature of 45.3° F was 3.2 F° warmer than average. In March, the trend at all the eleven stations shifted to colder-than-average, and this trend was more or less continued throughout the remaining months till the end of 1955.

Minor deflections from this colder-than-average trend were remarked for single months at Entrance Island and Departure Bay, where the August monthly means were 0.8 F° warmer than average. Cape Mudge, Ivory Island and Cape St. James had slightly warmer than average (0.3 F°) temperatures in June.

There appeared to be some similarity in the degree of departure from average temperatures between stations of the same oceanic type. For instance, Race Rocks and Pine Island showed a fairly constant colder-than-average departure of 0.8 F° to 1.0 F° during the period March to October, and in November and December at both stations the departure extended to 2.0 F° colder-than-average.

The comparison of 1955 temperatures from all seventeen stations with those for the previous year (1954) showed considerable variation, but the net effect was for 1955 temperatures to be colder than those in 1954. At most stations, the 1955 January and February monthly mean temperatures were warmer. November and December monthly mean temperatures at all stations were definitely colder than in 1954, with November usually showing the largest difference. This amounted to 4.5 F° for both months at Amphitrite Point and McInnes Island, and at many of the other stations it was about 3.0 F°.

Seawater temperatures during 1955 at Swiftsure Lightvessel were at a maximum (52.5° F) in July - August and at a minimum (44.3° F) in March.

Seawater Salinities: The 1955 monthly mean salinity data obtained at the long-term stations showed no common month-to-month trend of differences when compared with the 10-year (1945-1954) average values. Usually the range of departures from average conformed to the concept of the physical oceanographic characteristics associated with the region in which the station was located. The widest departures from average were shown at those stations that come into the influence of the fresh water runoff from large rivers. At Entrance Island in Georgia Strait the 1955 June mean salinity of 26.30 °/oo was 2.84 °/oo higher than the 10-year average salinity, but the August salinity mean of 21.87 °/oo was 2.70 °/oo lower than the 10-year average. Langara Island's location can be classified as "exposed to open ocean". Here the greatest departure from average, in February, was only 0.45 °/oo and throughout the year the monthly mean salinities were lower than average. Pine Island, which can be classified as a "turbulent seaway", recorded monthly mean salinities during each month of 1955, with the exception of January, that were higher than average, with the maximum departure being 0.5 °/oo in May.

Comparing the 1955 salinities with those for 1954, there was a large amount of variability noted in month-to-month trends of the differences, just as had been noticed in the comparison with the 10-year averages. In the records from six of the stations it was clearly evident that 1955 salinities were generally higher than those for 1954. At Langara all the 1955 monthly mean salinities were average or lower-than-average. The other stations exhibited variable month-to-month differences. A regional similarity in salinity conditions was noted in some of the stations located in Georgia Strait. At Entrance Island, Departure Bay, Texada Mines and Cape Mudge the 1955 monthly mean salinities are all higher than those for 1954. In general, the monthly fluctuations were proportional to the distance from the Fraser River. Beaver Point and East Point, in the southern regions of Georgia Strait, showed different patterns for the 1955-1954 monthly differences.

There was no definite seasonal pattern of variation in the salinity of the surface water at Swiftsure. It was generally about 31.5 ‰ but it was noticed that it was always higher than at Amphitrite Point, farther north along the Vancouver Island shore.

During the past year several statistical researches have been commenced which interpret these data so that they can be used to delineate normal and abnormal coastal conditions (Tabata-this report). Studies by Herlinveaux (this report) have shown that the observations at Race Rocks can be extended in scope to describe the seasonal variations that can be expected in the surrounding regions of the Strait of Juan de Fuca.

Volume XV, 1955, of the series, "Observations of Seawater Temperature and Salinity on the Pacific Coast of Canada" will be published early in April, 1956. It is planned to supplement the daily records with annual graphs of the temperature and salinity observed at each station.

Coastal Shipping Temperature Observations: A valuable adjunct to the daily seawater observations are the surface seawater temperatures being taken by four Canadian tug-boats operating in British Columbia coastal waters. This program was commenced in August, 1954 by the Port Meteorological Officer in Vancouver, and the records are collected by him and sent to the Pacific Oceanographic Group. The observers take surface water temperatures every six hours along the route of the ship's tow. The routes extend from Hecate Strait to the Juan de Fuca Strait. No analysis has yet been made of these data but they could, combined with the daily seawater temperature data, provide indices of seasonal and regional changes in British Columbia coastal temperatures.

H. J. Hollister

Ocean Weather Station "Papa" Bathythermograph Observations

The program of twice-daily bathythermograph soundings to 450 feet depth at Ocean Weather Station "Papa" (50° N., 145° W.) has been continued throughout 1955. There has only been a total of thirty-five days in which observations were missed, and none of these periods were for longer than ten days. The observations were missed because of rough weather, and breakdowns in the worn-out electric sounding winches. It is hoped to install new bathythermograph winches on both ships in the summer of 1956. The excellent observational record of 1955 is due entirely to the commendable efforts of the personnel of the two Department of Transport ships, C.G.S. "Stonetown" and C.G.S. "St. Catharines".

A definite seasonal cycle of temperature has been observed down to a depth of 250 feet. This pattern has been quite similar each year during the 3 1/2 year period of Canadian observations, but the values change from year to year. Below this depth, the water temperature does not vary more than 2 F° the whole year, and the seasons are not readily noticeable. From November to December the ocean to 250 depth is isothermal. In March and April, the coldest period of the year, this isothermal layer deepens to 400 feet. In May, the surface waters commence to warm and this warm layer extends downward in varying amounts as the summer progresses. The maximum temperature at the surface is reached in August; at the 100-foot depth in September; and at the 200-foot depth in October.

In April, the surface temperatures were 0.4 F° colder than the 1953-1954 period. This cold trend continued and increased until by August the monthly mean temperature of 52.3° F was 5 F° colder than those for 1952, 1953 and 1954 (Canadian observations at "Papa" commenced in July, 1952). The remaining months of the year showed temperatures about 2 ot 3 F° colder than in the previous three years. This deficiency in surface heat was reflected in lowered temperatures, to a lesser extent, at the 100-foot depth and 200-foot depth during most of this nine-month cold period. During the first three months of 1955 the temperature at 450 feet depth was slightly (0.5 F°) warmer than it had been in the previous two years. The 1955 water temperatures were very similar to those of 1950 (observed by the U.S. Coast Guard ships that occupied "Papa").

Surface temperatures at Station "Papa" follow a seasonal trend of cooling and warming similar to that in the British Columbia coastal waters. Station "Papa" surface temperatures in 1955 were 4 to 5° F colder than those at Amphitrite Point on the west coast of Vancouver Island for the first six months of the year until July. During the latter half of the year the difference between temperatures at the two locations reduced from 3° to 2 F°.

A synopsis of the daily water temperature data at the four depths of 0, 100, 200 and 400 feet is presented in the annual volumes of the daily seawater data. A specially prepared reproduction of all the twice-daily bathythermograms obtained during the months of August, September and October, 1955, was included in the Canadian NorPac Data Record.

H. J. Hollister

Classification of Daily Sea Water Data

It is necessary to classify the large amounts of data originating in the daily sea water data if they are to be interpreted. The proposed technique is to assign rank to the observed values depending on their statistical departure from the smoothed annual cycle. This type of classification allows direct comparison of data from any observatory or over any period of time.

In the seasonal or monthly classifications, the grand monthly means of variables (e.g., sea temperature) obtained from fifteen years of observations are considered as representing the average state. The magnitudes of the individual monthly means are then compared statistically to the grand monthly means. Those falling within the limits of the probable errors (0.675σ) are considered normal and are given the rank $\pm$A. Those falling between this limit and the standard deviation $\pm$ (0.675σ to σ) are above or below normal with rank $\pm$B. Between the standard deviation and the fiducial limit $\pm$ (σ to 2σ) the values are much above normal, ranked $\pm$ C, and beyond this limit they are regarded as abnormal ($\pm$D).

An example of this classification is shown in Table I using the daily sea water temperature data from Triple Island lightstation. The years 1947 and 1948 may be considered as representing average years because of the few extremes in them. The year 1940 is an example of an abnormally warm Summer and 1950 an example of an abnormally cold Winter.

This method can also be used for first order correlation using the ranked deviations of one series with those of another.

TABLE I

Triple Island Surface Sea Temperatures

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1940	+C	+C	+C	+D	+D	+D	+C	+C	+C	+C	+C	+C
1941	+C	+C	+C	+C	+C	+C	+C	+C		+C	+B	+C
1942	+B	+C	+C	+B	+B	+B	+D	-B	-C			
1943						-B	-C	-C	-C		+B	+B
1944	+B	+B						-C	-C		+C	+C
1945	+C	+B				-B	-B		-C	-C	-C	-B
1946										-B	-C	-C
1947	-C	-B						+C				
1948											-B	-C
1949	-C	-C	-C	-C			-B			-B		-B
1950	-D	-C	-C	-B	-C				+B		-C	
1951				-B	-B			+B		-C		-B
1952						-C		-C		+C	+B	
1953								+B	+C		+B	+B
1954				-B	-B	M I S S	I N	G	+C	-B		

Note: Months whose values fall within the probable error (rank ± A) are omitted from the Table.

With some modification, this method of classification is applied to short-term variations such as those of daily sea temperature and salinity through an individual year. A reference curve is drawn through the monthly mean values. The standard deviation and probable errors are computed from the differences of observed values and those from the reference curves. Deviations are classified in the same manner as before. Examination of temperature and salinity shows that there are about three major deviations occurring every month in both of these variables. At present this method is being applied to the daily sea water observations along the coast of British Columbia.

S. Tabata

Hecate Project - Water Masses in the Hecate Region

Seven oceanographic surveys in the Hecate region were scheduled for the period May, 1954 to June, 1955. These surveys (Table I) have been completed and the data reported.

TABLE I

Catalogue of Oceanographic Cruises

Cruise	Period	Ship
H-54-1	May, 1954	H.M.C.S. "Cedarwood"
H-54-2	July, 1954	C.N.A.V. "Ehkoli"
H-54-3	August, 1954	H.M.C.S. "Cedarwood"
H-54-4	December, 1954	H.M.C.S. "Cedarwood"
H-55-1	February, 1955	H.M.C.S. "Jonquiere"
H-55-2	April, 1955	H.M.C.S. "Jonquiere"
H-55-3	June, 1955	H.M.C.S. "Cedarwood"

The data indicate that surface salinities are low, 30 to 32 °/oo, over the entire area during all seasons. There is a gradient from oceanic salinities along the seaward side of the area, to lesser values along the mainland shore. In Dixon Entrance, surface salinities are generally less than in either Hecate Strait or Queen Charlotte Sound. Dilution from land drainage and precipitation is evident in all seasons, particularly in the southeast and northeast sectors, and along the mainland coast.

In general the volume of fresh water entering the region exhibits two yearly peaks. One occurs during the late Autumn, generally November, and coincides with the occurrence of the yearly maximum precipitation. The second occurs during the Summer when the rivers and streams are swollen with melt water from the winter snows stored at high elevations, and in the interior.

The two principal rivers, the Skeena and the Nass, which carry off melt water from the interior drainage basins reach a peak volume in late May and early June. Other smaller rivers which drain the immediate coastal region reach a summer maximum in July and occasionally as late as August. This difference in time of occurrence of peak runoff is exhibited by the salinity data obtained from the daily sea water observations made at Triple and Ivory Island. Triple Island, located close to the mouth of the Skeena River, indicates a minimum in June close to the time of peak Skeena runoff. Ivory Island, located farther to the south and removed from large rivers, indicates a minimum summer salinity in July and August in phase with the peak runoff from the coastal regions.

The existence of a halocline as observed in offshore waters is not a marked feature of the Hecate data. There is, in general, no marked transition from an upper layer of low salinity water to the deeper high salinity water. Vertical salinity gradients are larger and shallower in Summer than in Winter.

The annual range of surface temperatures varied between 7° C in the Winter (February) and 14° C in the Summer (August). Little consistent variation normal to the coast was observed. In general, the surface waters of Dixon Entrance were colder than the waters farther south.

A temperature structure does exist and varies seasonally. In the Spring and Summer the surface waters are warmed and a thermocline is developed which becomes more pronounced as the Summer progresses. In the Autumn and Winter the near surface waters become homogeneous due to cooling and extensive wind mixing.

In any one season both the salinity and temperature structures are dependent to a considerable degree on position.

Another principal feature of the Hecate data is a seasonal variation of temperature and salinity of the deeper waters. This water is warmer and less saline in Winter than in Summer. The effect is most marked in the inshore regions and becomes less with distance to seaward.

During the Autumn and Winter the southeast winds are much stronger than during the Summer. In the Autumn, under the influence of these winds, surface water is moved toward the mainland coast, then northward parallel to it. This lighter surface water is accumulated in the coastwise region causing a compensating offshore movement of the deeper water. The observed variation in temperature and salinity is brought about when this deeper water is replaced with the less saline, summer warmed, surface water.

In the Spring, when the intensity of the southeast winds decrease, a relaxation occurs. The accumulated surface water moves offshore with a compensating inshore movement of the deep, colder, more saline water from the ocean.

The seasonal variation of the prevailing southeast winds is the chief factor causing the Summer and Winter distribution of temperature and salinity of the deeper water. The oceanographic data indicates further that certain variations in the timing and extent of these type water conditions probably occur. The data of 1954 suggest that Winter conditions were endured until July, while those of 1955 suggest that an abrupt return to Summer conditions took place between February and April. The occurrence of this phenomenon is being related to the occurrence of south-east winds. It is noted that the greatest variability in winds occurs during the Spring and least variability during the Autumn. It would be expected therefore that little variation would occur in the onset of Winter conditions while considerable variation may occur in the return of Summer conditions.

F. G. Barber

Heat Budget Studies

Various terms of the heat budget equation were examined to understand more fully the processes causing the fluctuation of surface sea temperatures and to gain some idea of the magnitudes involved in such processes.

Pertinent meteorological data and surface sea temperature data from 1947 to 1955 at Triple Island have been used in the analysis. In addition to these, oceanographic data obtained during the Hecate surveys (1954-1955) and bathythermograph data taken at Swiftsure Lightship have been used to compare the heat transfer at the sea surface at Triple Island and the actual loss or gain of heat from the water column in the two general locations, Dixon Entrance and Juan de Fuca Strait.

In Table I are shown the grand monthly means (1947-1954) of the incident solar radiation, cloud cover, reflectivity, solar radiation corrected for cloud cover, absorbed portion of solar energy, effective back radiation, evaporation, conduction, and the total heat transfer across the air-sea boundary at Triple Island.

The amplitude of the annual cycle of solar radiation is the largest of the terms in the heat budget equation and contributes most to the annual variation of heat transfer at the sea surface. Under observed cloud conditions at Triple Island, only one-half of the solar radiation reaches the sea surface and is subsequently absorbed into the sea. The maximum and minimum periods of heating occur in June and December respectively and are in phase with the radiant energy.

Heat lost by effective back radiation is relatively constant (25% variation from the mean). It is a minimum during the Summer and a maximum during the Winter. Since the amplitude is relatively small, it does not contribute much to the annual variation of the heat transfer.

The annual cycle of evaporation is quite marked. It is greatest in the Winter and least in the Summer. The transfer of sensible heat was computed using Bowen Ratios and multiplying with the evaporation values. The annual cycle of this term is in phase with that of evaporation and varies from a maximum loss in the Winter to a small gain in the late Summer. The magnitudes of the combination of evaporation and conduction are almost comparable to those of the amplitudes of solar radiation. Therefore, they are also of major importance in the variation of heat transfer. In Winter these terms are dominant.

The main feature of the total heat transfer across the air-sea boundary is that the greatest loss (more than 300 g.cal./cm.^{2}/day) occurs during a short period in the Winter (December, January) whereas the maximum gain (more than 200 g.cal./cm.^{2}/day) occurs in a longer period in the Summer (May to August). Periods of no net heat transfer occur in the latter part of March and September.

During the year there was a net loss of 20% of the total heat. However the errors involved in the computation of the heat budget terms are large and may exceed 20%, therefore it is not too easy to make specific conclusions about this net loss. At present it is assumed that it is real to some degree and that in order to maintain heat balance the deficit must be supplied by advection of warm water.

An examination in the change of heat content of a column of water in Dixon Entrance revealed some interesting features. During the period from July to August, 1954 there was actually a decrease (about 100 g.cal./cm.^{2}/day) of total heat content when the net gain at the sea surface was about 230 g.cal./cm.^{2}/day. In Juan de Fuca Strait a similar drop in the heat content occurred. This implies that a mass of cold water moved into the areas. This was probably due to the intrusion of upwelled water. Between August, 1954 and February, 1955 the decrease of heat content was about 30 g.cal./cm.^{2}/day in Dixon Entrance and Juan de Fuca Strait, when there was a mean loss of heat at the sea surface of about 150 g.cal./cm.^{2}/day at Triple Island. This may be due to northerly transport of warm water into the region under the influence of southerly winds that prevailed during this period.

S. Tabata

TABLE I

Rate of Heat Energy as Expressed in g.cal./cm.^{2}/day.

(Positive if Heat Received by Sea.)

	Incident Solar Radiation (direct and scattered)	Cloud Cover (tenths)	Reflectivity	Incident Solar Radiation (corrected for cloud cover)	Solar Radiation Absorbed by Water	Effective Back Radiation	Evaporation	Conduction	Total Heat Transfer Across Air-Sea Boundary
Jan.	132	7.20	0.17	65	54	-105	-171	-118	-341
Feb.	242	7.55	0.13	112	97	-106	-120	- 70	-198
Mar.	420	7.15	0.09	207	188	- 96	-100	- 37	- 49
April	612	6.95	0.08	310	285	- 91	- 74	- 7	+103
May	762	7.55	0.07	354	329	- 84	- 40	+ 5	+214
June	825	7.65	0.07	377	350	- 88	- 58	+ 4	+214
July	770	7.60	0.07	353	328	- 84	- 30	+ 10	+229
Aug.	645	6.95	0.08	327	300	- 86	- 22	+ 10	+201
Sept.	482	6.95	0.09	244	222	- 88	- 35	+ 19	+114
Oct.	295	7.95	0.11	128	114	-102	-112	- 26	-127
Nov.	160	7.95	0.16	70	59	-108	-118	- 53	-219
Dec.	104	8.10	0.19	45	36	-119	-171	-115	-369

Hecate Project - Current Observations

Observations of current speed and direction were made at a number of positions throughout the area. The majority of this work was carried out from H.M.C.S. "Cedarwood" while anchored, generally to one anchor with reduced scope. Observations were made hourly at the surface using a controlled current drag, and at subsurface depths using an Ekman meter.

These data reveal that rotary currents of tidal period are general, with excursions up to eight miles. Maximum streams vary with position and were of the order of 1/2 to 1 1/2 knots. The time of these maximum strengths generally occur about the time of mid-range for the tide along the shore. Similarly, where a time of slack water or minimum tidal stream could be inferred they occur close to the times of high and low water.

Net movements have been calculated for each depth at each station. These indicate that the net movements are small, usually between 5 and 10 miles per day. The largest movements were generally observed in the surface waters, although at a number of positions the net movements occurring at intermediate depths and close to bottom were the greatest.

The data suggest that a seasonal variation of net water movement occurs in Hecate Strait. In May a small but persistent southerly movement was observed, while in early September a northward movement was becoming apparent. It is considered that these seasonal variations of net movement in this region are wind dominated.

In June, seaward of the northern end of Vancouver Island, a slow movement of the deeper water to the northeast into Queen Charlotte Sound was noted. At shallower depths a slow movement was directed to the southeast, parallel to the shores of Vancouver Island. All the net movements in this region were of the order of 5 miles per day.

In June stations were occupied at several positions in the southeastern sector of Queen Charlotte Sound. At this time the net movements were apparently related to the discharge of fresh water from runoff and it is expected that they will vary seasonally with the discharge. In the region just west of the Virgin Rocks the net movements at all depths were directed to the south and west. They tend to confirm the existence in the summer of a clockwise circulation around the Goose Island banks indicated by the synoptic survey data.

The pattern of net movements with depth observed in Queen Charlotte Strait, off Pine Island, is consistent with the known distribution of water movement in regions where fresh water from land drainage is entering the sea. The fresh water moves persistently seaward entraining sea water from below to form an upper brackish layer; a movement of deep water takes place in the opposite direction toward the source of the fresh water. The observed net movements (Table I) clearly indicate the extent of the seaward movement in the upper layer and the landward movement in the deep layer. A depth of no net motion occurs at about 50 meters.

TABLE I

Depth (m)	Velocity (cm/sec)	Direction of Movement
0	-23.5	Offshore
10	-20.5	"
20	-15.5	"
30	- 9.9	"
50	- 1.3	-
75	+14.3	Onshore
100	+15.6	"
125	+16.4	"

F. G. Barber

Hecate Tidal Model

A very important part of the Hecate project is to determine the tidal and non-tidal current, the circulation systems, and their controlling factors. Currents in the region are due to winds, tides and density gradients. In nature these components are combined in varying degrees, from time to time and place to place, to produce the resultant currents and circulation patterns. Appreciation of the kinetics requires that the contribution of each component be recognized. Prediction of the system requires that the factors governing each be predictable.

In approaching this problem it was realized that the resultant currents could be observed. Hence if two of the components could be evaluated independently, the third could be determined by differences. The contribution of the density gradients may be computed readily from the oceanographic data. Barber and Tabata (this report) are making intensive studies of these factors.

Direct current observations were undertaken and have been described by Barber in this report - Current Observations. Tidal analyses were undertaken. The cycles of velocity and direction were related to the difference of tidal height from the ocean (Clayoquot) to the mainland side of the region (Prince Rupert). It was planned to complete a grid of such stations. It was anticipated that with the aid of the Tide Tables the currents at all stations could be predicted to a single day. Hourly current charts could be prepared showing the vectors at each station, and these could be resolved to show the circulation. This procedure was successful in Juan de Fuca Strait and Seymour Narrows. The method failed in the Hecate region because the proportionality and phase differences between the tidal and current cycles was found to be variable. It became evident that the tidal currents had a complex structure and could not be simply related to the tides tabulated for the region. Thus far it has not been possible to define the characteristic features of tidal circulation.

It is probable that the general current systems are fairly stable but it is doubtful if they could be discovered with these sea procedures, even if the observations were indefinitely prolonged.

The current pattern might be solved by simultaneous series of observations at thirty or more positions in the area. This is uncertain, and in any case would require more ships, personnel and equipment than are available.

In view of the difficulties in obtaining reliable current data, and the prohibitive expense of developing a network of current stations for the entire region, alternative approaches were sought. It was concluded that some form of model would be required.

A tidal model of the region can, in principle, be a theoretical model to be analysed by numerical techniques, or it can be a physical analogue based on equations governing circulation.

A theoretical model is preferable because it provides a more satisfactory understanding of the circulation in terms of the fundamental laws of fluid motion. In practice, however, it is difficult to set up an adequate theoretical model of tidal circulation which can be analysed numerically - even with the aid of the most advanced computing machines.

The region is sufficiently large so that the effects of the Earth's rotation cannot be neglected. If these are considered, the computations required to determine the tidal currents in a body of water with the simplest geometrical boundaries becomes extremely involved. If the Earth's rotation is neglected the task of computing the tidal currents in a region of irregular shape and depth is still a formidable one. Furthermore, the theoretical model cannot be generalized to include vertical velocity structure or friction because of the lack of numerical techniques to analyse such a model.

A more promising approach is offered through the use of a physical analogue; particularly a hydraulic model. The hydraulic model can be constructed to take into account many details of shore line and bottom topography. The effects of bottom roughness, fresh water runoff, and non-tidal currents can be determined by suitable modifications of the model. The observer is able to obtain synoptic pictures of the circulation at any stage of the tide, or a detailed picture over many tidal cycles at any point in the model. This may be done with a minimum expenditure of effort as compared with obtaining similar information from the prototype or a theoretical model. The hydraulic model is of considerable value as a visual aid to the observer and can be used to point out regions of special interest in the prototype.

A disadvantage of the hydraulic model is that geometric and kinematic similarity cannot be preserved while simulating a region of this size. As a consequence, the model cannot be relied upon to give complete detailed information about the prototype and must be carefully compared with the prototype to ascertain the limits of reliability. Another disadvantage of this model is that its size precludes the possibility of building it on a rotating platform so that the effects of the Earth's rotation could be simulated. However, it is possible to compensate for this by applying numerical corrections to the velocities observed in the model. Simple methods for such corrections are being studied.

A complete analysis has been made of the geographic features, the model laws, and the construction components.

The hydraulic model (104 feet by 45 feet) includes the whole region of the surveys. It is a distorted scale, single-fluid model, using block construction with cement surface. Tides are to be generated across the oceanic approaches by gates hinged along the bottom and controlled by a seven-component Kelvin tide machine. Observation of the movement of dye patches in the water are to be made photographically from a 90-foot tower. This will be comparable to aerial photography, from a height of 360 miles. A tidal day (24 hours, 50 minutes) requires only 62 seconds in the model so that the cumulative effects of tidal circulation over a period of time may be observed quickly.

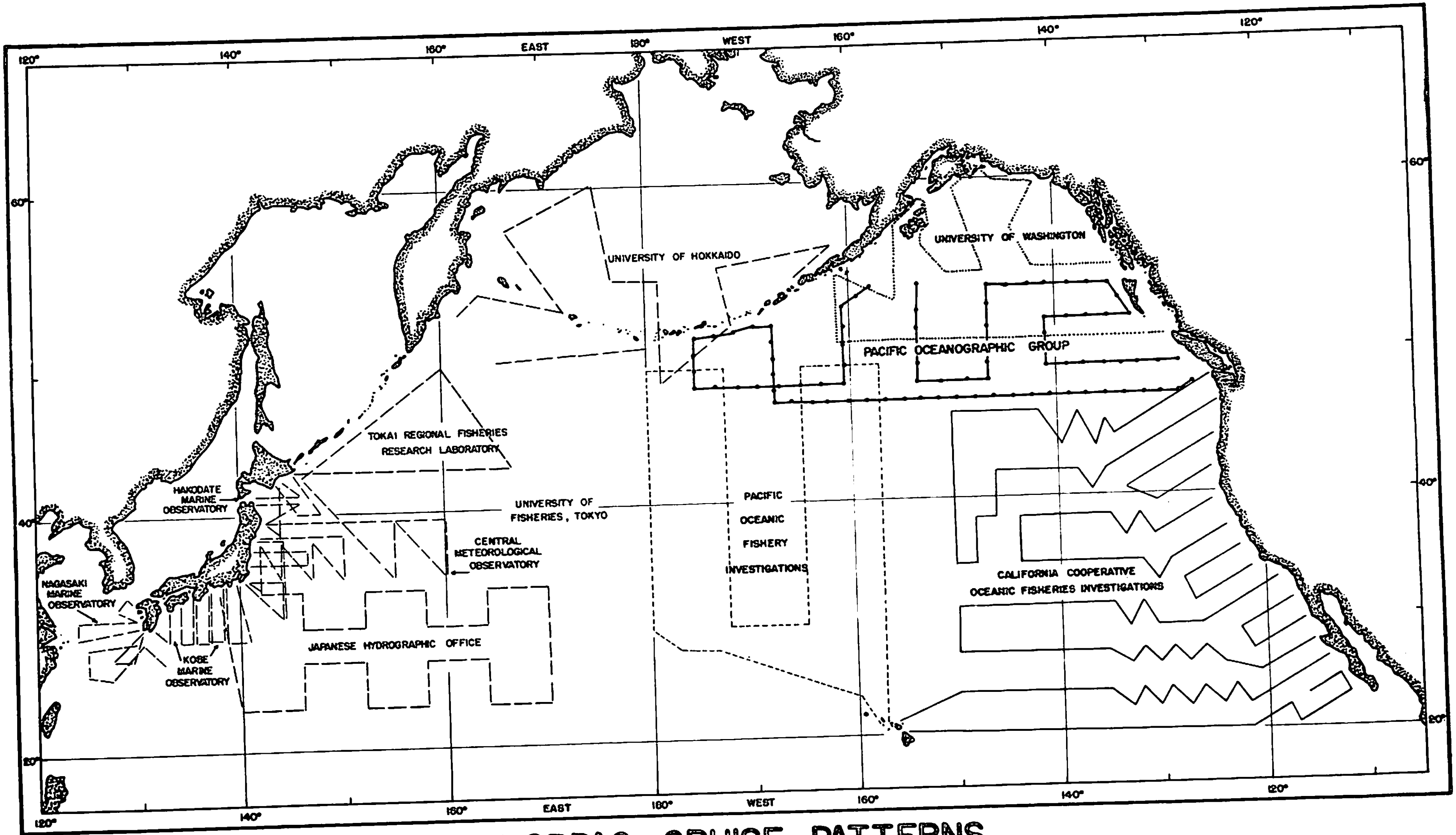
N. P. Fofonoff

Project NorPac

Project NorPac was undertaken as a synoptic survey of the North Pacific Ocean extending from Latitude 20° N., to the Bering Sea and from the North American coast to the east coast of Asia. During July, August and September agencies of Japan, United States and Canada combined their facilities and completed the greatest project of its kind ever undertaken. In all twenty vessels occupied about 1200 oceanographic stations according to an agreed plan, as shown in the accompanying diagram.

The Canadian expedition departed on July 26th in the R.C.N. frigate H.M.C.S. "Ste. Therese" under the command of Lt. Commander W. F. Potter. It returned 37 days later on September 1st after having cruised 7,160 miles and accomplished its mission.

Eighty-five stations were occupied at which observations of temperature and water samples were taken at intervals from the surface to 1,200 metres depth. Aliquots of the samples were analysed on shipboard for dissolved oxygen and inorganic phosphate. Aliquots were taken to the base laboratory for salinity determination. Further aliquots were sent to the United States Atomic Energy Commission and to the Scripps Institution of Oceanography for radio-activity tests. Samples were also collected for "Heavy Water" analyses. Two hundred and sixty-seven bathythermograph lowerings were made, one at each station and an average of two between each station. Plankton was collected to 400 metres depth at each station. Geomagnetic current measurements were made in part of the area. Fishing was not attempted



NORPAC CRUISE PATTERNS
August 1955

but sea and bird life was noted. Weather observations were also made four times daily.

Each agency carried out a similar program and processed its own data and prepared data records. These were exchanged at a meeting in February at Honolulu, so that each group has a complete set of records of the entire operation.

The first analysis of the data indicates some important oceanographic features off our coast.

The salinity and temperature structure along with the general circulation has been discussed fully in the following section. However the horizontal surface distribution of temperature, salinity, oxygen and phosphate can be discussed briefly.

South of Latitude 48° N. there is a gradient of increasing temperature and salinity toward the sub-tropic waters of the mid ocean. North of this, in the Gulf of Alaska, there is a gradient of salinity which can be associated with land drainage increasing from the shore towards the centre of the region. The temperature distribution is not so definite as the salinity. The waters along the mainland coast were somewhat warmer than those in the centre of the region. Along the Alaskan peninsula and the Aleutian Islands there is a border of cold water.

The principal oceanographic feature is found in the centre of the Gulf. Here, there exists a region of cold saline water. Associated with this are found high dissolved inorganic phosphate concentrations and low dissolved oxygen. The dynamic height shows that there is a cyclonic centre associated with this cold saline water. Around this there is evidence of a slow cyclonic movement.

A. J. Dodimead

Salmon Water

The first analysis of the NorPac data indicates its importance in our own area. Here we are primarily concerned with the association of water structure to the distribution of salmon.

The surface sea water temperatures are shown in Figure 1. The coldest waters were observed north of Latitude 48° N. along the Aleutian Islands, and in the Gulf of Alaska. In these regions the temperatures were between 10° and 12° C. These were the maximum Summer temperatures experienced during 1955. In mid-ocean south of Latitude 38° N. the temperatures were generally above 24° C and increased slightly towards the Tropics. Between these warm and cool regions there was a marked gradient of temperature.

In the northern region the temperature structure varies seasonally as shown in Figure 2A, the surface waters being warm in Summer and cold in Winter. In the Summer a warm homogeneous upper zone, 10 to 20 metres in depth is formed. Below this is a thermocline. This is a transition zone in which there is a marked temperature gradient between the warm upper zone and the cold waters of the deep ocean. In the Winter the waters cool. In the Gulf of Alaska the temperatures in the upper 150 metres of depth decrease to about 5° C the same as the deeper ocean water, and the thermocline vanishes.

In the Tropics the upper zone of warm water and the thermocline are present throughout the year.

Figure 3A shows representative Summer and Winter sea water temperatures along the surface. Their difference is the seasonal temperature range which decreases from north to south. Because of this seasonal range, temperatures greater than 12.5° C are found as far north as Latitude 48° N. in mid-Summer. By late Winter only the waters south of Latitude 38° N. are this warm. Thus any such temperature boundary shifts with the seasons.

The character of the water also depends on its salt content, which is independent of temperature. Figure 3B shows that the surface salinity decreased generally from south to north somewhat similar to the Winter temperatures. Figure 3C shows the distribution of salinity with depth in a longitudinal section from the Tropics to the northernmost part of the Gulf of Alaska on Longitude 147° W. (the dashed line in Figure 1). The salinity structure in the northern and southern waters is distinct. In the Gulf of Alaska the salinity increases with depth; in the sub-Tropics it decreases.

South of Latitude 38° N., in the sub-Tropics, the surface salinity is high (greater than 35 °/oo) and becomes less toward a minimum (34.00 °/oo) at 600 metres depth. This structure occurs at all times of the year.

A typical salinity structure in the gulf is shown in Figure 2B. In the upper 60 to 100 metres of depth the salinity is low; less than 32.8 parts °/oo. Below this to about 170 metres depth there is a halocline in which the salinity increases by one part per thousand or more. Below this the salinity increases gradually towards the great depths. This structure was observed north of Latitude 40° N. all across the Pacific Ocean from Asia to the North American coast, and in the southern part of the Bering

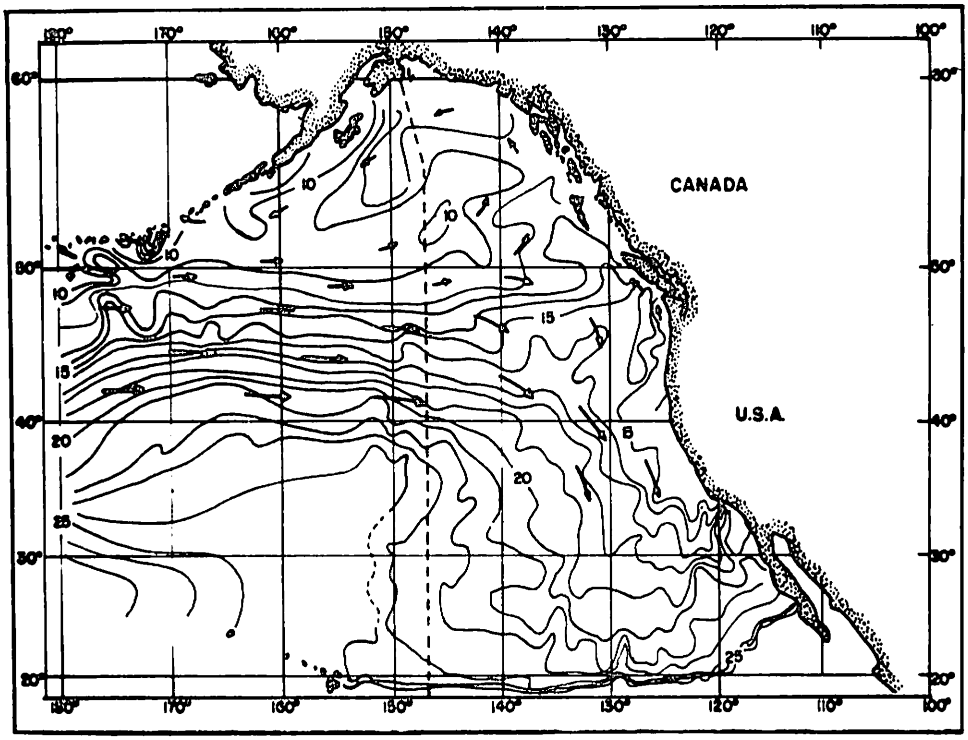


Figure 1.

Surface temperature distribution and currents in the Northeast Pacific Ocean, Project NorPac, 1955

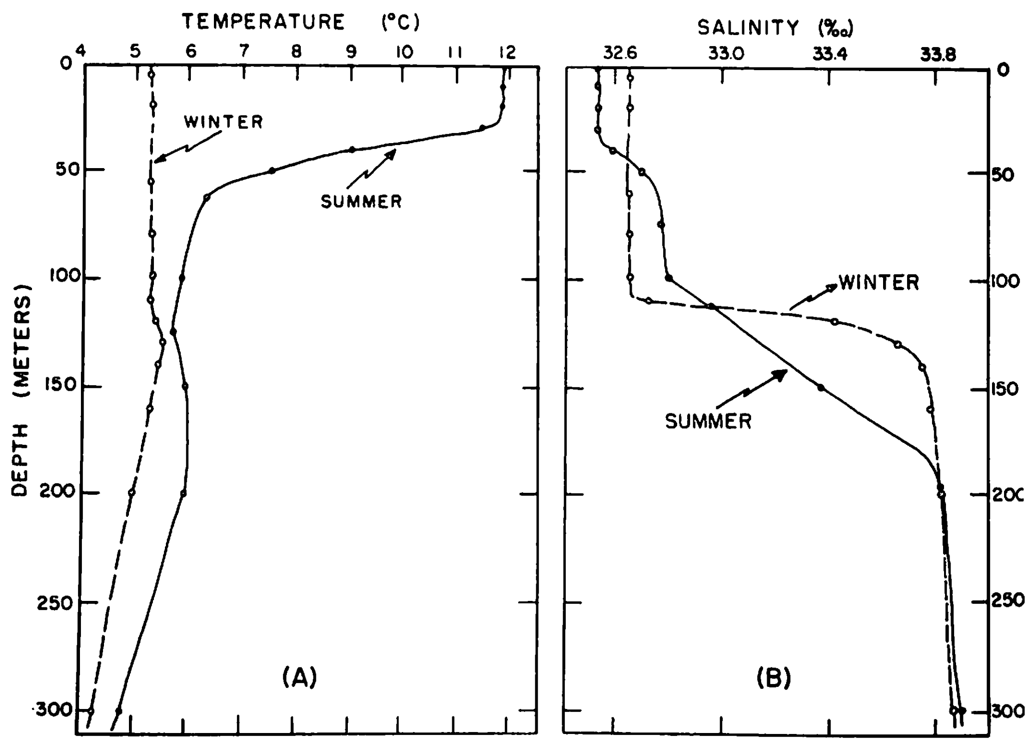


Figure 2.

(A) Representative temperature and (B) salinity structure in the Gulf of Alaska during the summer and winter.

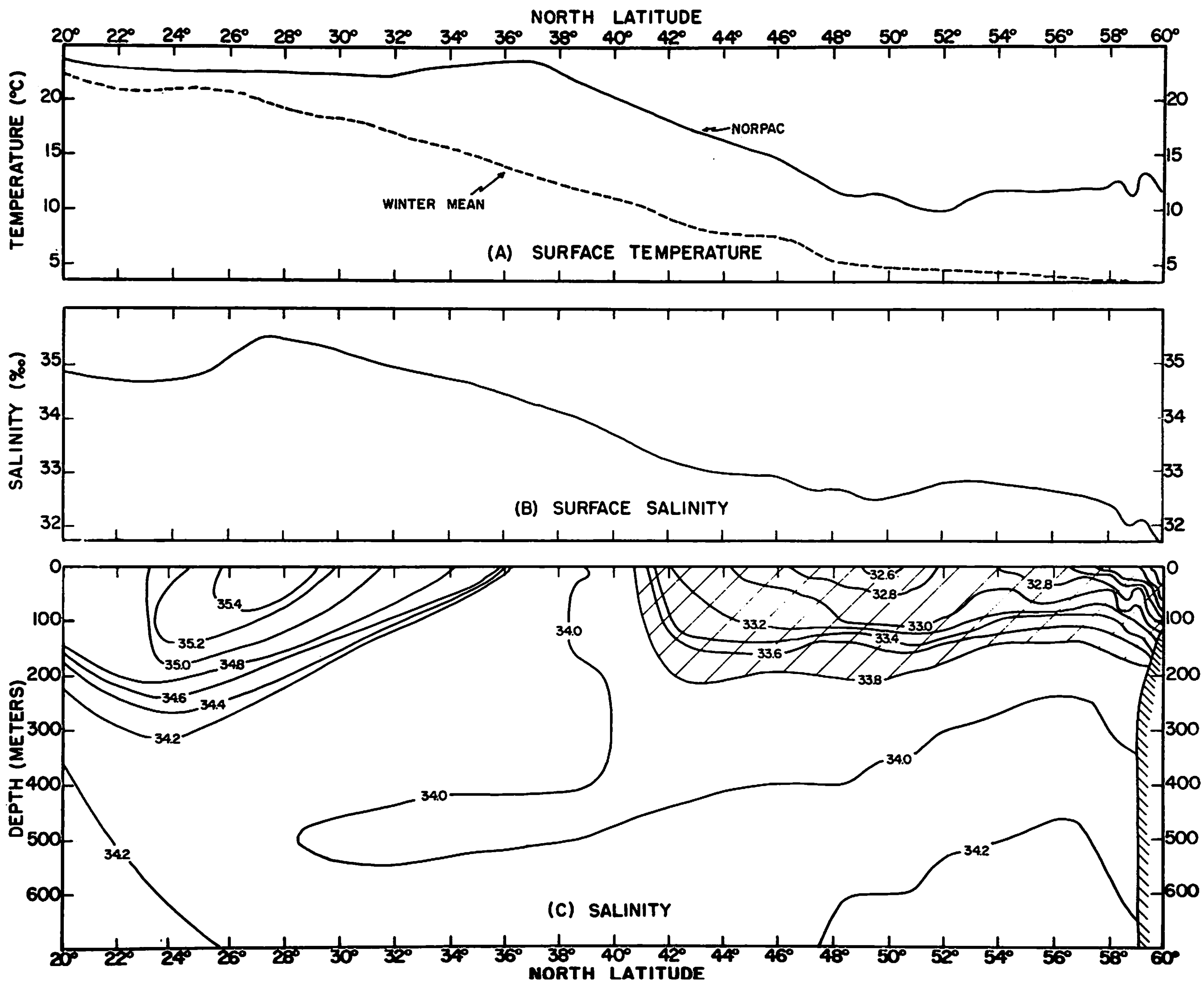


Figure 3.

(A) Surface sea water temperature, (B) surface salinity and (C) salinity-depth section along longitude 147° W., NorPac, 1955.

Sea. It is the same structure that is observed in the Canadian and Alaskan coastal waters. Previous surveys show that this surface zone of low salinity occurs throughout the year (Figure 4B). The halocline, unlike the thermocline in these regions, is a permanent feature of this area.

There are three distinct regions. The mid-ocean region south of Latitude 38° N. is the sub-Tropics. Here the surface waters are warm and saline in all seasons. Both the temperature and the salinity decrease with depth. North of Latitude 40° N. the structure is as shown in Figure 2B and 3C. Between these two regions there is a boundary in which the salinity is constant from surface to 500 metres depth and there is no halocline. Although there are data showing that the northern and southern structures exist throughout the year, there are no data showing the Winter position of this boundary. It is difficult to say whether it shifts with the season, or is more or less fixed.

The fishing experience around the north Pacific shows that salmon occur in all the coastal waters north of Latitude 42° N. These have the same temperature and salinity characteristics as the sub-Arctic waters in the Gulf of Alaska. Recent data from exploratory fishing by United States and Japanese agencies during the Summer of 1955 indicates that salmon occur in the waters having these properties, but do not occur outside of them. The temperatures of these waters vary greatly through the year. In the coastal region the salmon tolerate temperatures from less than 5° to 20° C. Salmon have not been sought on the high seas in Winter, but it is reasonable to assume that they would not desert the northern seas because of the low Winter temperatures.

The salinity of the upper zone remains low all year round in the coastal waters where salmon are known to occur, and in the northern offshore waters where they may be anticipated. Exploratory fishing for Albacore has not encountered salmon in the region of high salinity, even in the Winter when the temperatures fall within the known range of tolerance. It appears probable that salmon are associated with the northern salinity structure; that is, an upper zone of low salinity bounded by a halocline.

The circulation of these waters is shown in Figure 1. There is a general easterly drift south of Latitude 52° N. The southern side of this drift has its origin in the Kuroshio Current. The water on the northern side of this current originates in the Bering Sea. As this drift approaches the North American continent part turns south flowing toward the Equator. The remainder turns north and moves slowly around the Gulf of Alaska. Most of this water is dissipated through the Aleutian Islands back into the Bering Sea. In these Summer data there was no evidence that any large proportion rejoins the easterly drift to form a gyral in the gulf. These movements are very slow, from 2 to 5 miles a day, so that the water requires a year or more to cross the ocean, or progress around the gulf.

A. J. Dodimead

Strait of Georgia

During the period 1930 to 1938 oceanographic observations were made in the Strait of Georgia. These included a monthly series of serial observations at a central position in the strait through fifteen months; a series of serial observations at positions around the strait, observed on each tidal extreme through one day, and repeated in Spring, Summer and Autumn; thermograph and daily observations of salinity at Departure Bay and several other stations; as well as a number of casual observations. These data include temperature, salinity, dissolved oxygen, phosphates, silicates, nitrates, and nitrites, and the pH.

These observations were limited by equipment, facilities, personnel, and lack of experience. By themselves they are inconclusive. However they can now be interpreted in the light of later experience, and provide an interesting and useful study of the properties of the water, and the mechanisms contributing to these properties.

Analyses of the data was undertaken in 1949 and has continued intermittently ever since. The mechanism of discharge and the dissipation of Fraser River water has been solved. The mechanism of daily heating and cooling, and seasonal cycle of temperature has been explained. The relation of tidal movement to these properties has been described. The relation of dissolved oxygen and pH has been described. The sources of the high phosphates and silicates has been shown. It has been shown that dissolved nitrates vary from zero to high values and may be the limiting factor in plankton growth.

This study deals with the properties of the water and the reasons for the levels rather than the overall physical picture. It has provided a vehicle for discussion and explanation of many of the oceanographic processes observed in the Pacific Coast region.

It is in its final stages of preparation as a companion work to the physical study recently completed by Dr. Waldichuk.

J. P. Tully

Juan de Fuca Strait

The Juan de Fuca Strait Project was undertaken to define the water masses, the physical properties of the water, and the currents throughout one year. Daily observations of surface sea water temperature and salinity have been made at Race Rocks since 1936. Also periodic observations from surface to bottom have been made at a number of positions.

The waters in the strait oscillate to and fro with the tides. The velocity and direction at any point bear a simple relation to the difference of sea level between the inner and outer ends of the strait. This phenomenon has been discussed in recent papers. In the upper waters, and along the Canadian shore, the ebb movement is stronger than the flood. These waters progress seaward. The flood movement is stronger in the deep waters, particularly along the United States side. These waters progress toward Georgia Strait. The surface and deep waters are mixed to a varying degree enroute, by the turbulence associated with the strong currents.

There is a longitudinal gradient of properties (temperature and salinity) from the inner to the outer end of the strait, from the characteristics of the Strait of Georgia to those of the coastal ocean water. In addition the properties in all parts of the region vary with time. Generally the range of variation is greatest at the inner end. It decreases to seaward as far as a line across the strait from Pillar Point to Glacier Point. From this line seaward the ranges of variation increase.

The surface sea water temperature and salinity vary through a cycle whose period is twelve and one-half hours, closely related to the tidal cycle. As the waters are moved back and forth by the tide, the properties at any point change in accord with the water mass which is advancing.

The surface sea water temperature and salinity oscillate through a cycle of fifteen days which is closely related to the spring and neap tidal current cycle.

The annual surface sea water temperature cycle shows a maximum in August (mean value 10.7° C) and a minimum in February (mean value 7.2° C). The annual cycle in the deep waters shows a maximum in January and a minimum in August. In consequence, the vertical structure tends to be slightly positive in Winter changing to a negative gradient of about 5° C in mid-Summer.

The annual surface salinity cycle shows two minima. One occurs in Winter (February) associated with the maximum precipitation and coastal runoff. The other occurs in the Summer (July) in consequence of the peak discharge of the Fraser River, and drainage from the melting snow at high levels. The intervening maxima occur in Spring and Autumn. The grand monthly mean salinities vary between 31.00 °/₀₀ and 31.50 °/₀₀. The greatest fluctuations are associated with the periods of lower salinity.

There is also a diurnal cycle in the surface sea water temperature associated with daylight heating and night cooling (afternoon effect).

Relations have been found between the daily observations of sea water temperature and salinity at Race Rocks, and the values of these properties in all parts of the strait. From this it is possible to recognize the oceanographic state in the region at any time.

R. H. Herlinveaux

Hydraulics of Salmon Spawning Gravels

During 1954 Messrs. Pollard and Wickett developed a method of measuring the flow of natural waters through the gravels of salmon spawning redds. They designed a 1 1/2 inch diameter standpipe whose lower end contained a perforated chamber. This chamber was sealed by a flat plate through which a 3/8-inch pipe extended to the upper end. The lower end of the standpipe was fitted with a point. In use the standpipe was driven ten inches into the gravel. Methylene blue dye was introduced into the chamber, and its rate of fading measured. This was found to be proportional to the hydraulic gradient (s) of the groundwater flow. The rate at which water must be pumped out of the standpipe, to maintain the level inside one inch below the level on the outside, was found to be proportional to the permeability (k) of the gravel. From these data the velocity of flow can be determined in the relation

$$V = ks$$

The standard standpipes (Mark II) were calibrated in a trough permeameter using a range of random gravels. Properties of the ground waters were determined on samples taken from the standpipe. This work has been published.

After a year's use a number of difficulties have appeared which have necessitated further research and modification of the equipment and procedure.

The points broke off the standpipe when they were being driven into the gravel. This breakage was eliminated by having the inner tube and seal of the lower chamber removeable. An iron bar is inserted through the pipe so that the driving force is exerted directly on the point. The pipe takes no strain.

The permeability of some natural spawning gravels was greater than the range of calibration of the Mark II standpipe. While extending this range, it was found that water friction in the 3/8-inch inner pipe limited the rate of inflow of water. However when the inner pipe and the seal of the lower chamber were removed there was no difficulty in making the measurements.

Previous measurements showed wide variability. This was partly due to the effect of the narrow inner pipe, and partly due to the fact that earlier calibrations were made in random gravels. Recently calibrations have been made in uniform gravels. In each case the observations are constant within ± 5% of the mean. This is useful because for each level of permeability there is a wide range of composition of random gravels. These can now be referred to the permeability in standard uniform gravels.

The use of methylene blue to measure the hydraulic gradient was questioned because the results continued to be erratic. The dye solution was considerably more dense than the groundwater. It leaked out of the standpipe chamber when there was no groundwater flow. Also the residue formed a lake in the bottom of the standpipe chamber. The original technique required frequent stirring which caused random losses of dye. It was found that methylene blue is readily absorbed on rusty iron, and is bleached by zinc and detritus in the water. It is unsatisfactory for the use in this test.

The dye difficulties were resolved by using a mixture of Tartrazene and Brilliant Blue FCF made up in 15% alcohol so that the specific gravity is 0.99975. This forms a green colour which does not adsorb or fade in use. It diffuses readily in the chamber of the standpipe, requiring no stirring, and does not leak out when there is no flow.

In the earlier standpipe the chamber was open to the inner pipe. The water in this pipe was not flushed in the same manner as the chamber. Its volume was about 40% of that of the chamber and was variable depending on the depth of water in the gravel and the stream. This source of error caused wide fluctuations in the observations. They have been eliminated by fitting a rubber membrane across the bottom of a removeable inner tube, and introducing the dye with a hypodermic needle. Thus the dye is confined to the lower chamber where the flushing characteristics are constant.

The new standpipe (Mark IV) appears to be satisfactory. It is a simple 1 1/2 inch iron pipe, with a point, and perforations around the lower end. It is driven into the gravel with a solid steel rod resting on the point. Permeability is determined by measuring the rate at which water must be removed to maintain the level inside the standpipe one inch below the level on the outside. A lower chamber is formed by introducing a diaphragm into the pipe with access through an inner pipe. The new dye is introduced into this lower chamber with a hypodermic needle. Its rate of fading is determined by sampling. No stirring is required.

It remains to calibrate this new model and prove it in field use.

L. D. B. Terhune

Sea Water Intrusion in Steveston Cannery Basin

In July, 1954 the Harbours and Rivers Engineering Branch of the Department of Public Works approached the Group for assistance. They wished to know if sea water intrusion occurred in the recently completed Steveston Cannery Basin, and if the unprotected pilings of the various wharves along the waterfront had been infested by shipworms (Bankia setacea).

In August, 1954 a weekly sampling program for salinity was instigated and continued for 15 months till October, 1955. On the basis of the first three months of observations, it was concluded that sea water intrusion occurred in the basin and that the salinity of the water was suitable for shipworm survival. The study was extended to determine if shipworms were present in the basin. After learning that they were, it was necessary to determine how they entered the basin, and whether they would continue to grow and cause serious damage. In addition, it was necessary to learn the extent of sea water intrusion in the adjacent river channel, to see if conditions there were more or less favourable for shipworm survival.

These problems suggested a coordinated oceanographic and biological investigation of the area. The latter was undertaken by Mr. R. J. LeBrasseur of the Biological Station, Nanaimo, B. C. The weekly sampling of sea water and the placement and removal of test blocks for shipworm infestation was made by the staff of the Department of Public Works. Four oceanographic surveys were made in the area, one in December, 1954, aboard C.N.A.V. "Ehkoli". The others were made by the staff of the Department of Public Works in April and May, 1955, under the direction of the Group.

During normal river discharge (50,000 to 150,000 cubic feet per second) sea water advances into the estuary on the flood tide, forming a salt wedge between the upper layer of fresh water and the river bottom. This sea water intrusion occurs in the mid-channel of the Fraser River outside Steveston Cannery Basin, and in the basin during most of each tidal day. There is no intrusion during the six weeks of freshet period from the time the discharge rises above 250,000 cubic feet per second until it falls to 180,000 cubic feet per second.

During the 10 1/2 months when intrusion occurs, the intruded sea water remains in the basin throughout the tidal day except at times of lowest low of the spring tides, when it is flushed for several hours. The river channel adjacent to the basin is flushed for a few hours during the neap tides and for longer periods during the spring tides. Flushing is more effective in the river channel than in the basin.

The upper ten feet of the water in the basin is relatively fresh but at five feet above the bottom the salinity of about 25 °/₀₀ endures for more than one-half a day, and along the bottom for more than three-quarters of a day. The maximum salinity of the intruded sea water is of the order of 28 °/₀₀.

Sea water remains in the "depressions" along the bottom of the basin throughout the tidal cycle. In these places it also remains during the freshet period even though the tidal intrusion is not occurring.

In view of this it was suggested that the basin be dredged on a uniform slope and all depressions filled. Furthermore, it was recommended that all depressions and cross-channel bars lying seaward of the basin be eliminated.

A two-current system exists in the basin; the currents in the upper layer of fresh water and the currents in the deeper layer of sea water. The maximum strengths of the deep currents occur about three hours after those in the upper layer. The maximum strengths of these currents are about 0.8 knots.

The temperatures of the intruded sea water are the same as those encountered at depths from 10 to 50 feet at the mouth of the river. The temperature of the upper layer is that of the river water.

The decrease in the concentration of dissolved oxygen toward the bottom of the basin is attributed to the demand made by the organic matter (black mud) lying along the bottom of the basin. This organic matter probably originated in the waste products from the canneries and domestic sources.

S. Tabata

Sea Water Analyses Laboratory

A specially-designed semi-automatic titrations laboratory comprising five units is available to analyse the great number of sea water samples received annually from the various field expeditions and daily sea water program.

The salinities of these samples are analysed to varying levels of precision. In the case of routine investigations (daily sea water observations, etc.) an accuracy of ± 0.06 °/oo is required. Where a high degree of precision is required for dynamic calculations (Western Arctic, NorPac) an accuracy of ± 0.02 °/oo is required. Last year 18,400 samples were titrated.

This service is also extended to analyse samples collected during observations by the Biological Station and the Pacific Naval Laboratory.

L. H. McCracken

Data Records

In recent years it has been the policy of this Group to publish, as soon as possible after the completion of an oceanographic survey, a record of the observed physical and chemical data. The data are arranged in tabular form with explanations of procedure of observation and analyses, and are published in the manuscript series of the Joint Committee on Oceanography.

During 1955, records of all the oceanographic observations taken during the Hecate Strait Project of 1954-1955 were published. Observations made in Barkley Sound during April, 1950 were published as well as those made in a series of surveys conducted in Steveston Cannery Channel during August to December, 1954. Other important data records published in 1955 include the observations made during the Juan de Fuca Strait Project in 1951-1952, and the recent NorPac oceanographic survey, August, 1955. The latter presents the physical and chemical data at interpolated and observed depths and uses a unique method of reproducing the bathythermograms obtained during the survey.

There remain quite a number of early oceanographic surveys whose data have not been published, but this back-log is steadily being processed. The following Table shows the status of the publication of data from major oceanographic surveys conducted by the Pacific Oceanographic Group since 1930.

Tabulation of data on file at Pacific Oceanographic Group and data records published to December 31, 1955.

Period of Obs'v'n	Region	Publication Status
1914 - 1955	Daily seawater observations, B. C. coastal locations	Continuing No. 1
1930-31, 1932	Strait of Georgia	1953, No. 2
July 24-27, 1933	Nootka Sound	Not published
April-July, 1934	Southwest coast, Vancouver Is.	" "
May-July, 1935	West coast, Queen Charlotte Is.	" "
Feb. 14-26, 1936	Southwest coast, Vancouver Is.	" "
June-Sept. 1936	Offshore, W. coast Vancouver Is.	1950, No. 3
Feb.-Oct., 1937	Approaches to Juan de Fuca Str.	Not published
Jan.-May, 1938	Approaches to Juan de Fuca Str.	" "
May-June, 1938	Dixon Entrance	" "
June-Nov., 1938	Swiftsure Bank area	" "
Oct.-Nov., 1939	Alberni Inlet	" "
April-June, 1941	Alberni Inlet and Harbour	Partial publication F.R.B. Bull. 83
1948-1949	Nodales Channel	Not published
May-Sept., 1948	Chatham Sound	" "
July-Aug., 1949	Bering and Chukchi Seas	Restricted U.S. Publication
1949,'51,'52,'53	Strait of Georgia	1954, No. 4
1949, 1950, 1951	Fraser River Estuary	1951, No. 5
April 4-26, 1950	Barkley Sound	1955, No. 6
May-Nov., 1950	Nodales Channel	Not published
Aug.-Nov., 1950	Bute Inlet	" "
1950-1951	Baynes Sound	" "

Period of Obs'v'n	Region	Publication Status
July-Oct., 1950	Offshore, W. coast Canada	Not published
1951	Bute Inlet	" "
1951	Nodales Channel	" "
May-Aug., 1951	Offshore, W. coast Canada	Part. Published 1952, No. 7
1951-1952	Juan de Fuca Strait	1955, No. 8
July 12-17, 1952	Hecate Strait (Current Survey)	Not published
June-Oct., 1952	Nodales Channel	" "
July 15-23, 1953	Inlets of B. C. coast	" "
May-Dec., 1954	Dixon Entrance, Hecate Strait, Queen Charlotte Sound	1955, No. 9 1955, No. 10
1954-1955	Steveston Cannery Channel	1955, No. 11
Aug.-Sept., 1954	Beaufort Sea	Restricted, U.S. Publication
Feb.-June, 1955	Dixon Entrance, Hecate Strait, Queen Charlotte Sound	1955, No. 12
July-Aug., 1955	Northeast Pacific Ocean	1956, No. 13
Jan.-May, 1955	Steveston Cannery Channel	Not published
Jan.-Dec., 1955	Daily seawater observations, B. C. coastal locations	" "

List of Pacific Oceanographic Group Data Record Publications

Manuscript Report Series of the Joint Committee on Oceanography

No. 1 Observations of Seawater Temperature and Salinity on the Pacific Coast of Canada, Volumes I to XIV, 1914 through to 1954. 1947-1955.

No. 2 Physical and Chemical Data Record, Strait of Georgia, 1930, 1931, 1932. July 1, 1953

No. 3 Pacific Coast Data Record, Offshore Survey, 1936. November 15, 1950.

No. 4 Physical and Chemical Data Record, Strait of Georgia, 1949-1953, with Appendix I, Current Measurements, March, 1953. May 1, 1954.

No. 5 Data Record, Fraser River Estuary Project, 1950. December 1, 1951.

No. 6 Data Record, Barkley Sound, April 4-27, 1950. December 15, 1955.

No. 7 Pacific Coast Data Record, Offshore Survey, August 1-14, 1951. July 1, 1952.

No. 8 Physical and Chemical Data Record, Juan de Fuca Strait Project, 1951-1952, with Appendix I, Current Measurements. April 30, 1955.

No. 9 Physical and Chemical Data Record, Hecate Project, 1954. January 15, 1955.

No. 10 Data Record, Current Measurements, Hecate Project, 1954. March 1, 1955.

No. 11 Studies in Steveston Harbour Basin. Part I. Sea Water Intrusion into the Steveston Harbour Basin, by S. Tabata. February 15, 1955.

No. 12 Physical and Chemical Data Record, Hecate Project, with Appendix I, Current Observations, 1955. August 15, 1955.

No. 13 Physical, Chemical and Plankton Data Record, Project NorPac, July 26 to September 1, 1955. February 1, 1956.

The oceanographic data files are kept in a concrete fire-proof vault. They are filed in a chronological order, within regional or project subdivisions. Each file folder is numbered and a data catalogue is kept. There is a free exchange of original unpublished oceanic data with the U.S. Navy Hydrographic Office in Washington, D.C. There the data are tabulated on Hollerith punch cards.

The many hundreds of bathythermogram records taken each year from such sources as the Royal Canadian Navy, Pacific Naval Laboratory, Canadian Hydrographic Survey and from the Pacific Oceanographic Group oceanographic surveys are filed chronologically within a geographical classification determined by latitude-longitude designators.

H. J. Hollister

Bathythermograph Calibration

A bathythermograph calibration unit was built by the Pacific Naval Laboratory and installed in the Model Laboratory in January, 1955. The unit consists of a pressure tank with heating, refrigeration, and pressure controls and recorders. A bathythermograph is sealed in the tank where it records the imposed temperature and pressure conditions on its smoked glass slide. A temperature-pressure (depth) grid is then fitted to this slide and recorded photographically. From this a standard calibration grid is made. These have been compared satisfactorily with grids prepared by the makers, Wallace and Tiernan Limited, and by Naval Research Establishment, Halifax.

With this equipment, calibration service is provided for the Royal Canadian Navy, Pacific Naval Laboratory, Biological Station, Institute of Oceanography, and Pacific Oceanographic Group. Thirty-six instruments have been calibrated during the past year.

The present unit will only accommodate one instrument (two instruments if all excess parts are removed). It would be much more efficient to handle a larger number, and Pacific Naval Laboratory is building a tank to hold five instruments.

R. H. Herlinveaux