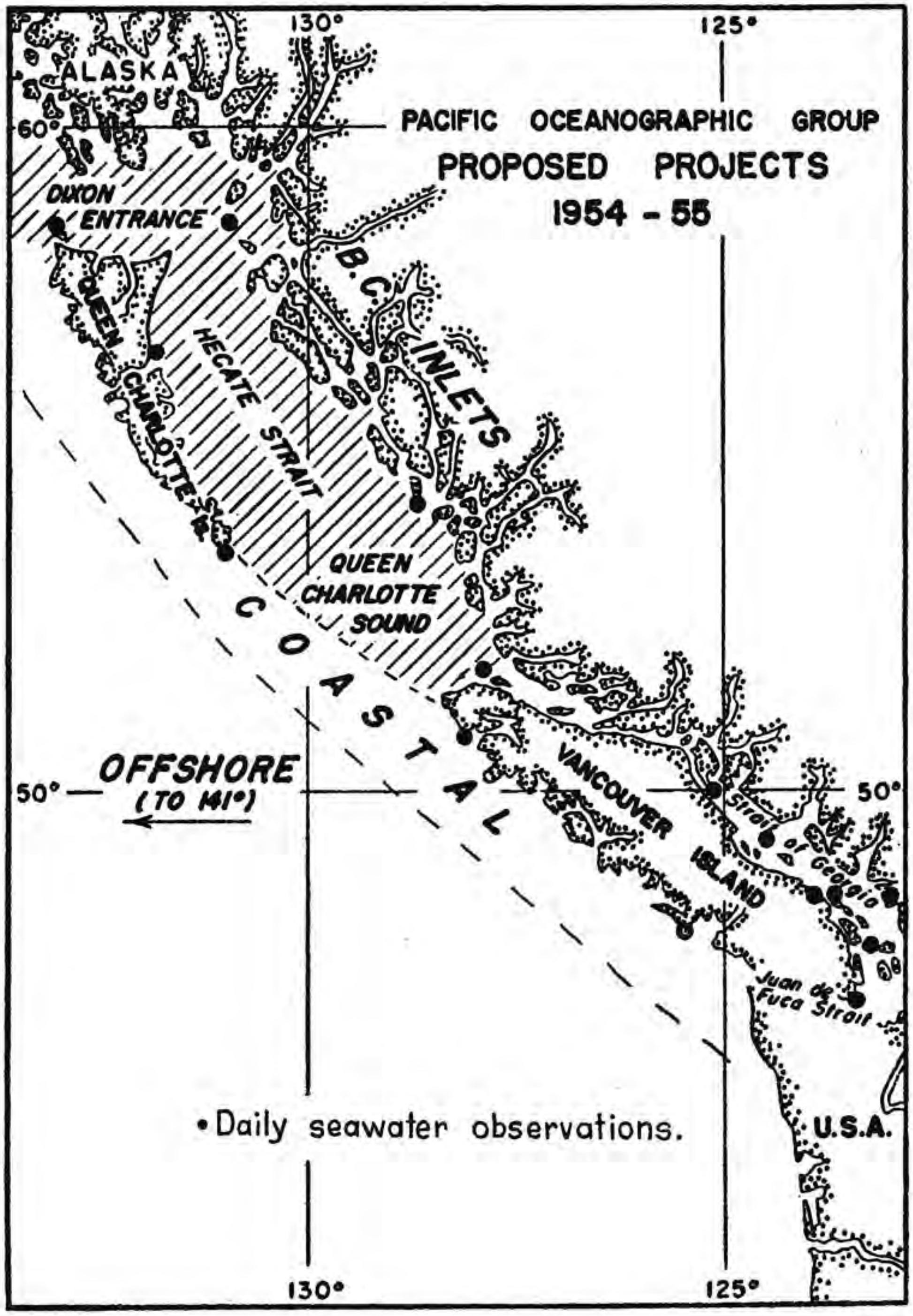
OCEANOGRAPHY ALONG THE CANADIAN PACIFIC COAST

by

J. P. TULLY

Pacific Oceanographic Group
Fisheries Research Board of Canada

A REVIEW OF EXISTING KNOWLEDGE WITH AN OUTLINE OF CURRENT RESEARCHES CONDUCTED BY THE PACIFIC OCEANOGRAPHIC GROUP OF THE FISHERIES RESEARCH BOARD OF CANADA.


PACIFIC OCEANOGRAPHIC GROUP
PROPOSED PROJECTS
1954 - 55
ALASKA
DIXON ENTRANCE
QUEEN CHARLOTTE
HECATE STRAIT
B.C. INLETS
QUEEN CHARLOTTE SOUND
COASTAL
OFFSHORE
(TO 141°)
VANCOUVER ISLAND
Strait of Georgia
Juan de Fuca Strait
U.S.A.
130°
125°
60°
50°
• Daily seawater observations.

OCEANOGRAPHY ALONG THE CANADIAN PACIFIC COAST

By J. P. TULLY

Pacific Biological Station, Nanaimo, B. C.

Oceanographic studies have been made in many parts of the region shown in the figure. This is divided into natural areas (offshore, coastal, a strait, or an inlet and only one area is studied at a time. Each study consists of oceanographic surveys in successive months or seasons (spring, summer, autumn, winter) through one or more years. In each survey an attempt is made to observe the temperature, salinity, and sometimes dissolved oxygen, at a series of depths from surface to bottom, at a grid of stations covering the area being studied. Every attempt is made to complete the survey quickly so that it may be as nearly synoptic as possible. The data from each study are compiled in a multilithed Data Record which is usually a restricted publication. This Data Record shows the position, depth, and conditions of each observation, the properties observed, and derived quantities such as density, dynamic height, etc.

Daily observations of sea water temperature and salinity at one yard depth are made at fourteen positions (Figure) along the coast. These data extend over various periods from 1914 to the present. Five of the stations are on the ocean coast and data are generally available from 1933 to the present. These data are published annually. They provided continuous definition of the oceanographic conditions.

These survey and daily observation programs are integrated in the study of the data. The surveys show the oceangraphic conditions over the whole area at one time, while the daily observations indicate the duration of such conditions, and the seasonal cycles of water properties.

The studies are published in Manuscript Reports (multilith) of the Pacific Oceanographic Group, Progress Reports of the Pacific Coast Stations of the Fisheries Research Board of Canada. Occasionally publication of methods or theory (not listed here) is made in other journals. Reprints of most of these papers are available.

General References.

ANONYMOUS.
1949 Annual Report, Pacific Oceanographic Group, 1949. MS. Report, 29 pp.

ANONYMOUS.
1950 Annual Report, Pacific Oceanographic Group, 1950. MS. Report, 37 pp.

ANONYMOUS.
1951 Annual Report, Pacific Oceanographic Group, 1951. MS. Report, 42 pp.

ANONYMOUS.
1952 Annual Report, Pacific Oceanographic Group, 1952. MS. Report, 45 pp.

ANONYMOUS.
1953 Canadian Joint Committee on Oceanography, Annual Report, 1952. Extracted from Annual Report, Fish. Res. Bd., pp. 137-147.

ANONYMOUS.
1953 Annual Report, Pacific Oceanographic Group, 1953. MS. Report, 52 pp.

ANONYMOUS.
1954 Annual Report, Pacific Oceanographic Group, 1954. MS. Report, 55 pp.

HACHEY, H. B.
1948 Canadian Joint Committee on Oceanography, Annual Report 1948. Extracted from Annual Report, Fish. Res. Bd., pp. 94-96.

POLLARD, R. A. and W. P. WICKETT.
1955 Measuring seepage through salmon spawning gravel. J. Fish. Res. Bd. Can., 12 (5). (In press).

TULLY, JOHN P.
1949 Review of Canadian Pacific Oceanography since 1938. Trans. Amer. Geophys. Union, 30 (6), pp. 1-9.

TULLY, JOHN P.
1954 Conditions for troll fishing. Prog. Rept. Pac., 101, pp. 12-16.

WICKETT, W. P. and R. A. POLLARD.
1954 Measuring the oxygen supply to salmon redds. Prog. Rept. Pac., 99, pp. 20-21.

Tides

The tidal rise is 10 to 12 feet near Juan de Fuca Strait and generally increases northward to about 22 feet in Dixon Entrance. The tidal currents along the ocean coast and Queen Charlotte Sound are strong (one knot or more) and rotary. In the inlets and large straits the tides are reversing and generally of the order of 2 to 3 knots. In the many narrows velocities frequently reach five or more knots, and at Seymour Narrows, velocities in excess of 13 knots are recorded. In all these passages the flow is turbulent and the waters are mixed to homogeneity from surface to bottom.

REFERENCES.

DOE, L. A. E.
1950 Tidal currents in Loudoun Channel. Prog. Rept. Pac., 84, pp. 70-71.

DOE, L. A. E.
1952 Currents and net transport in Loudoun Channel, April 1950. J. Fish. Res. Bd. Can., 9 (1), pp. 42-64.

HERLINVEAUX, R. H.
1953 How to predict tidal currents in Juan de Fuca Strait. Prog. Rept. Pac., 95, pp. 48-51.

HERLINVEAUX, R. H.
1954 Surface tidal currents in Juan de Fuca Strait. J. Fish. Res. Bd. Can., 11 (1), pp. 14-31.

HERLINVEAUX, R. H.
1954 Tidal currents in Juan de Fuca Strait. J. Fish. Res. Bd. Can., 11 (6), pp. 799-815.

LACROIX, G. WILFRED and JOHN P. TULLY.
1954 The anomaly of mean sea level in Seymour Narrows, B.C. J. Fish. Res. Bd. Can., 11 (6), pp. 853-883.

MACKAY, BRUCE S.
1954 Tidal current observations in Hecate Strait. J. Fish. Res. Bd. Can., 11 (1), pp. 48-56.

Offshore

The first offshore oceanographic survey was made in July and August, 1936. It included the area within 100 miles of the coast of Vancouver Island. These observations have only been reported partially.

In 1950 to 1952 a series of five oceanographic surveys was made covering the area off the Canadian coast westward to Longitude 141°W., in August, October, November 1950 (frustrated by weather), May 1951, August 1951, and March 1952. These data showed that there was an upper zone, 100 to 150 meters deep, in whch all seasonal variation occurred. Below this is a deep zone extending to at least 1,000 meters depth, which is independent of local weather. The upper zone is fresher than the deep zone and separated from it by a notable halocline. In winter the upper zone is the colder and in summer it is the warmer of the two zones.

The calculated currents indicate that the movement in the area is small and indeterminate. Evidently the West-Wind Drift Current crosses the ocean between Latitudes 46 and 51°N. About 600 to 800 miles off shore it divides, part turning south to form the California Current, and part turning north to form the Alaska Gyral. The area off the Canadian coast is one of confused eddies between these major currents in the upper zone.

It appears evident that the latitude of the division of the West-Wind Current may vary from year to year, thus altering the character of the water in this region. In 1950 and 1951 it appears that the division was about Latitude 48°N, and the general trend of movement in this area was northward. However, the 1936 data indicates that the division was further north because the general movement was southward.

Considerable study will be required to solve this system and predict its behaviour. The task was originally undertaken to assess the boundary of the coastal waters. This end has been served.

REFERENCES.

ANONYMOUS.
1950 Pacific Coast Data Record, Offshore, 1936. MS. Report, 39 pp.

ANONYMOUS.
1952 Pacific Coast Data Record, Offshore Survey, August 1-14, 1951. MS. Report, 5 pp.

DOE, L. A. E.
1951 Sea-surface temperatures, 1950-51. Prog. Rept. Pac., 88 pp. 53-56.

DOE, L. A. E.
1952 Oceanographic studies off the Canadian Pacific Coast, 1951. MS. Report, 7 pp.

DOE, L. A. E.
1954 Offshore waters of the Canadian Pacific Coast. J. Fish. Res. Bd. Can., (submitted for publication).

TULLY, JOHN P.
1937 Gradient currents. Prog. Rept. Pac., 32, pp. 13-14.

TULLY, JOHN P. and E. B. BENNETT.
1952 Project "Offshore", coastal temperatures and tuna. Prog. Rept. Pac., 92, pp. 6-9.

TULLY, JOHN P.
1953 Some characteristics of sea water structure. MS. Report, 21 pp.

TULLY, JOHN P. and L. A. E. DOE.
1953 Surface waters off the Canadian Pacific Coast. MS. Report, 7 pp.

WALDIE, R. J., L. A. E. DOE and ASSOCIATES.
1950 Oceanographic Discovery. Prog. Rept. Pac., 84, pp. 59-63.

Coastal

An intensive study of the temperature, salinity, dissolved oxygen and dynamics was made in the approaches to Juan de Fuca Strait from 1935 to 1938. These data have only been partially analysed. Rather cursory surveys of the coastal waters along Vancouver Island were made in 1933, 1934, and 1937 during the summer. These have not been reported.

In general, there is a strong northward coastal current, within five miles of shore. This current is strongest during the winter (southwest winds) and weakest during the summer (northwest winds). Near the shore the water is cold, 10°—11°C in summer and becomes warmer to seaward, reaching 15° to 18°C about 60 miles offshore. In winter the coastal temperature is only slightly less (8°—10°C) but the water becomes colder to seaward reaching 5° to 6°C about 60 miles offshore. In general, the coastal waters are freshest in winter coincident with the maximum coastal drainage.

REFERENCES.

TULLY, JOHN P.
1937 Oceanography of Nootka Sound. J. Biol. Bd. Can., 3 (1), pp. 43-69.

TULLY, JOHN P.
1937 Report on dynamic studies off the Canadian Pacific Coast, 1936. Trans. Amer. Geophys. Union, 18th Annual Meeting, pp. 228-231.

TULLY, JOHN P.
1937 Why is the water along the west coast of Vancouver Island so cold? Prog. Rept. Pac., 34, pp. 13-15.

TULLY, JOHN P.
1938 Some relations between meteorology and coast gradient currents off the Pacific Coast of North America. Trans. Amer. Geophys. Union, 19th Annual Meeting, pp. 176-183.

TULLY, JOHN P.
1942 Surface non-tidal currents in the approaches to Juan de Fuca Strait. J. Fish. Res. Bd. Can., 5 (4), pp. 389-409.

TULLY, JOHN P.
1952 Notes on behaviour of fresh water entering the sea. 7th Pac. Sci. Cong., III, 23 pp.

TULLY, JOHN P.
1952 Climate in the coastal seas of British Columbia. Prog. Rept. Pac., 90, pp. 16-20.

WALKER, E. R.
1954 Marine Weather Services on the British Columbia Coast. MS. Report, 6 pp.

Inland Seas

Thorough and extensive studies of the properties of the water and the currents have been made in Juan de Fuca Strait, Georgia Strait, Chatham

Sound, Alberni Inlet, and Bute Inlet. More general observations and cursory descriptions have been made of many other inshore areas and inlets.

In all these seaways the fresh water from land drainage moves persistently seaward entraining ocean water from below to form a brackish upper zone which becomes more saline to seaward. Below this layer, and separated from it by a notable halocline is the deep zone of ocean water which moves persistently towards the sources of fresh water. The salinity and temperature of the upper zone vary with the season, while the properties of the lower zones are very nearly constant.

This structure is destroyed by the turbulence in the many passes and narrows around the coast where the tidal currents are rapid and violent.

REFERENCES.

ANONYMOUS.
1951 Data Record, Fraser River Estuary Project, 1950. MS. Report, 489 pp.

ANONYMOUS.
1953 Physical and Chemical Data Record, Strait of Georgia, 1930, 1931, 1932. MS. Report, 78 pp.

ANONYMOUS.
1953 The oceanographic phase of the Nanaimo sewage problem. MS. Report, 35 pp.

BARBER, F. G.
1954 Water masses in Queen Charlotte Strait. Pro. Rept. Pac., 100, pp. 6-7.

BARBER, F. G. and S. TABATA.
1954 The Hecate oceanographic project. Prog. Rept. Pac., 101, pp. 20-22.

CAMERON, W. M.
1948 Fresh water in Chatham Sound. Prog. Rept. Pac., 76, pp. 72-75.

DOE, L. A. E.
1952 Currents and net transport in Loudoun Channel. J. Fish. Res. Bd. Can., 9 (1), pp. 42-64.

FJARLIE, R. L. I.
1950 The oceanographic phase of the Vancouver sewage problem. MS. Report, 21 pp.

NUTTALL, J. B.
1950 Hydraulic model of Alberni Harbour, Interim Report. MS. Report, 15 pp.

PICKARD, G. L.
1953 Oceanography of British Columbia mainland inlets. I. Water characteristics. Prog. Rept. Pac., 96, pp. 3-6.

PICKARD, G. L.
1953 Oceanography of British Columbia mainland inlets. II. Currents. Prog. Rept. Pac., 97, pp. 12-13.

PICKARD, G. L.
1954 Oceanography of British Columbia mainland inlet. III. Internal waves. Prog. Rept. Pac., 98, pp. 13-16.

PICKARD, G. L.
1954 Oceanography of British Columbia mainland inlets. IV. Dissolved oxygen distribution. Prog. Rept. Pac., 99, pp. 9-11.

SHAND, J. A.
1953 Internal waves in Georgia Strait. Trans. Amer. Geophys. Union, 34 (6), pp. 849-856.

TABATA, S.
1954 The problem of sea water intrusion in Steveston Cannery Channel. MS. Report, 6 pp.

TABATA, S.

1954 Oceanography of British Columbia mainland inlets. V. Salinity and temperature of waters of Bute Inlet. Prog. Rept. Pac., 100, pp. 8-11.

TULLY, JOHN P.

1949 Oceanography and prediction of pulp mill pollution in Alberni Inlet. Fish. Res. Bd. Can., Bull. 83, 169 pp.

TULLY, JOHN P. and A. J. DODIMEAD.

1955 Properties of the water in Georgia Strait. J. Fish. Res. Bd. Can., (submitted for publication).

WALDICHUK, M.

1952 Oceanography of the Strait of Georgia. I. Salinity distribution. Prog. Rept. Pac., 93, pp. 26-29..

WALDICHUK, M.

1953 Oceanography of the Strait of Georgia. II. Temperature distribution. Pro. Rept. Pac., 94, pp. 19-23.

WALDICHUK, M.

1953 Oceanography of the Strait of Georgia. III. Character of the bottom. Prog. Rept. Pac., 95, pp. 59-63.

WALDICHUK, M.

1953 Oceanography of the Strait of Georgia. IV. Dissolved oxygen distribution. Prog. Rept. Pac., 96, pp. 6-10.

WALDIE, R. J.

1950 Fresh water in Georgia Strait. Prog. Rept. Pac., 83, pp. 42-44.

WALDIE, R. J.

1951 Winter oceanography of Baynes Sound and the Lazo Bight. MS. Report, 9 pp.

Institute of Oceanography, University of B.C.

ANONYMOUS.

1953 Data Report No. 1, British Columbia inlet study, 1951. MS. Report, 79 pp.

ANONYMOUS.

1953 Data Report No. 2, British Columbia inlet cruises, 1952. MS. Report, 14 pp.

TRITES, R. W.

1953 Oceanography of Chatham Sound. MS. Report No. 3, 32 pp.

Seasonal Cycles

The discharge of the large rivers, particularly along the mainland coast, is greatest in May and June, when the snow melts in the mountains. The discharge of the small rivers on Vancouver, Queen Charlotte and other coastal islands is greatest in the winter, coincident with the maximum coastal precipitation. Thus the influence of the big rivers is greatest in summer, while the influence of the small rivers is maximum in the winter.

Temperature is almost entirely due to local insolation. The temperature of the upper zone water increases from March to mid-September, while the air is warmer than the water. From then until March the temperatures decrease while the air is the colder. The greatest range of water temperatures occurs in sheltered harbours and bays. The temperature range of the large straits such as Georgia Strait is intermediate between the bays and the ocean. The most constant temperatures occur in the passes and narrows where the waters are continually mixed to homogeneity.

Further north, near the Bering Strait the shallow water occurs in homogeneous masses, clearly defined by haloclines and thermoclines. Most of the boundaries are vertical and are indicated at the surface by tide rips (convergences).

REFERENCES.

OCEANOGRAPHIC STUDIES SECTION, Research Division, U.S.N.E.L., and P.O.G.
1954 Oceanographic cruise to the Bering and Chukchi Seas, summer 1949. (Submitted for publication).

Present Operations

An intensive study of the oceanography of Queen Charlotte Sound, Hecate Strait, and Dixon Entrance is being undertaken. This includes observations of the physical and chemical properties of the water and the currents.