FISHERIES RESEARCH BOARD OF CANADA

MANUSCRIPT REPORT SERIES
(OCEANOGRAPHIC and LIMNOLOGICAL)

No. 186

Oceanographic Atlas of the Subarctic Pacific Region
Summer 1961

by
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Nanaimo, B.C.

January 16, 1965

Programmed
by
THE CANADIAN COMMITTEE ON OCEANOGRAPHY
INTRODUCTION

Dodimead, Favorite and Hirano (1963) recently published "Review of Oceanography of the Subarctic Pacific Region", in which features of the water structure and circulation are reviewed; regions, water masses and domains are identified; seasonal and yearly variations of temperature, salinity and oxygen for the years 1955 through 1959 are discussed. During the subsequent years, oceanographic agencies of Japan, United States of America and Canada have gathered data in the Subarctic Pacific Region; but as yet, no one has presented composite synoptic pictures from these data. Such pictures are necessary in order to have an appreciation of the continuity or lack of continuity of properties throughout the Region in any one period. Further, they facilitate comparison of oceanographic features and extent of domains with those in other years; all of which are needed in order to study the oceanic distribution and migration of various stocks of salmon in relation to oceanographic features and their variations.

This work is presently being done under the research program of the International North Pacific Fisheries Commission (INPFC).

This report presents the published data for the Subarctic Pacific Region for the summer 1961 in the same format used in the above review and in other manuscript reports (Pacific Oceanographic Group, 1959; Dodimead, 1960). Portions of these data have been presented and discussed elsewhere (INPFC, 1963; Favorite and Morse, 1964).
DATA

The oceanographic data used in this report were gathered by several agencies during the period May through September. The sources of data are given in Table I.

PRESENTATION OF DATA

(a) Horizontal Plots

The surfaces on which temperature and salinity are presented are those used by Dodimead, et al (1963). These surfaces are associated with features of the water structure as shown in Figure 2. The significance of each of these surfaces is described.

(1) 10 metres depth - Properties at this level are representative of those in the surface-mixed layer (surface to top of seasonal thermocline in summer, or surface to top of halocline (upper zone) in winter (Fig. 2)). Tully and Giovando (1963) define the former layer as the "potential layer depth".

(2) Bottom of upper zone - The bottom of the upper zone (top of halocline) is the limit of winter convection when the layer becomes isopycnal. Dodimead (1961) concluded that, within small limits of error, summer conditions at this level reflect the local conditions in the upper zone during the previous winter (at the time of minimum temperatures) in the eastern Subarctic. He postulated that this conclusion was applicable to the remainder of the Subarctic Pacific Region. If such is the case, temperature and salinity distributions on this surface would be similar to those for the previous winter through the whole depth of the upper zone. Further, the temperature minimum layer, generally called dicothermal water, and the bottom of the upper zone are usually coincident (Fig. 2, plates B and C).
<table>
<thead>
<tr>
<th>Date of Cruise</th>
<th>Vessel</th>
<th>Agency</th>
<th>Data Publication</th>
</tr>
</thead>
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<tr>
<td>June 14-July 22</td>
<td>&quot;Oshoro Maru&quot;</td>
<td>The Faculty of Fisheries, Hokkaido University.</td>
<td>Data Record of Oceanographic Observations and Exploratory Fishing - No. 6. The Faculty of Fisheries, Hokkaido University, Hokkodate, Hokkaido, Japan. March, 1962.</td>
</tr>
<tr>
<td>May 20-Aug 5</td>
<td>M.V. &quot;Paragon&quot;</td>
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<tr>
<td>May 28-July 1</td>
<td>C.N.A.V. &quot;St. Anthony&quot;</td>
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</table>
(3) Surface of salinity = 33.8\% - The distributions of properties on this surface can be used to define the character of the water at the boundary of the halocline and lower zone. There are several reasons for using the surface of salinity = 33.8\% instead of interpreting the bottom of the halocline: this level corresponds very closely (± 0.1\%) with the surface of salinity = 33.8\%; in the western Subarctic, the salinity discontinuity which defines the bottom of the halocline is not always present; and, except for the most westerly part of the Region, the temperature maximum layer (mesothermal water) lies close to this surface (Fig. 2, plate B).

(4) Surface of salinity = 34.0\% - The surface of salinity = 34.0\% lies well within the lower zone, thus properties and their distributions on this surface are considered to represent the lower zone characteristics to about 1000 metres depth.

(b) Vertical Sections

Several vertical sections of salinity, temperature and dissolved oxygen are presented. The positions of the sections are shown in Figure 15.

Remarks concerning figures:-

1. Currents (Fig. 3)

Since the distributions of various fields of this Region are more easily interpreted when the general character of the flow pattern has been established, the geopotential topography and geostrophic currents are presented first.

In Figure 3, the geopotential topography of the 50 metre surface relative to 800 metres is presented. The 800 metre surface was used because there are not enough data to greater depths to form the basis of a comprehensive picture.
When possible a deeper reference surface is recommended, since it would produce the same circulation pattern and would give more realistic values of the magnitude of the geostrophic currents.

The choice of the 50 metre surface rather than 0' metres was made in order to eliminate the effect of seasonal heating over the period of the surveys. The fact that stations in the same area, but widely separated in time, have similar dynamic heights at 50 metres suggest that the assumption of steady state for the cruise periods is reasonable, and a realistic concept of the general circulation at this level is obtained.

Although, in Figure 3, the flow pattern is that for 50 metres, it is also characteristic of the flow at the surface. The magnitudes of the surface currents have been determined between pairs of stations using the deepest reference level common to each pair of stations.

2. Temperature (°C) at 10 metres depth (Fig. 4)

Because of seasonal heating, it is impossible to combine all the observed data and draw a meaningful synoptic chart of near-surface temperatures. For this reason, Figure 4 shows 10 metre temperature distributions for different periods in adjacent areas.

In the eastern Subarctic, the surface seawater temperature curve for Ocean Station "P" (Lat. 50° N, Long. 145° W) has been used to adjust all observed data in this area to a common period, June 10. The assumption is that the net heat gained at any locality is the same as that at Ocean Station "P". This method gives a reliable synoptic picture for the eastern Subarctic.

For the remainder of the Region, except for the small area off the coast of Japan, the isotherms were constructed principally from July data. Off the coast of Japan, the temperature distribution is that for August.
3. Salinity at 10 metres depth (Fig. 5)

Except near the coast, local seasonal variations in the salinity of surface water have generally been small (± 0.2%). Therefore, most of the data can be combined to give a representative synoptic picture for the summer period. In Figure 5, the solid isopleths are a result of contouring data taken during the period June through July. The dashed lines represent August data.

South of the Aleutian Islands, the effect of the dilute water from the periphery of the Gulf of Alaska becomes readily apparent in August (dashed lines).

In the far western Subarctic, although the early and late summer data are identified, it appears from the isohalines that a picture could be constructed from all the data and which would be representative of any part of the summer period.

4. Depth of, temperature and salinity at bottom of upper zone (Fig. 6, 7, 8)

These charts were constructed using all data. The location of the bottom of the upper zone was interpreted from plots of temperature and salinity (natural scale) versus depth (logarithmic scale).

5. Depth of, and temperature on, the surface of salinity = 33.8% (Fig. 9, 10)

All the data have been used to construct these charts, as changes in the deep or non-seasonal zone are relatively slow, particularly during this period.

Off the coast of Japan, near the Subarctic boundary, the structure is complicated by the presence of one or more salinity minima, resulting in the presence of two or more surfaces of this salinity. In all cases the deepest level has been used.

6. Depth of, and temperature on, the surface of salinity = 34.0% (Fig. 11, 12)

As in (5) all the data have been used to construct these charts.
Near the Subarctic boundary, where the occurrence of a salinity minimum at intermediate depths results in the presence of two surfaces of salinity = 34.0%, the deeper surface is used. Water at and below this level is continuous with that in the Subtropic Region.

7. Domains (Fig. 13, 14)
Dodimead, et al (1963) introduced the concept of domains which contains the idea of consistent properties, structure, behaviour (flow, heating and cooling, etc.) climatic locality and continuity. Based on their criteria, the various upper and lower zone domains for summer 1961 have been identified.

8. Vertical Sections (Fig. 16-25)
The vertical sections were constructed by determining the depth of the isopleths from plots of properties (natural scale) versus depth (logarithmic scale). Features such as the Subarctic Boundary and the Alaskan Gyre are identified in the sections.

REFERENCES


Figure 1.
Figure 2. Salinity and temperature structures in the Subarctic Pacific Region.
Figure 3.
NORTH PACIFIC OCEAN
TEMPERATURE (°C)
AT 10 METRES DEPTH
SUMMER 1961
— JUNE (observed data corrected to June 10 for seasonal heating observed at Ocean Station "P")
—— JULY
—— AUGUST

Figure 4.
Figure 5.
Figure 6.
Figure 8.
Figure 9.
Figure 10.
Figure 11.
Figure 12.
Figure 15.
Figure 16. Vertical sections of salinity and temperature along Long. 146°E, summer 1961.
Figure 17. Vertical sections of salinity and temperature along Long. 150°E, summer 1961.
Figure 18. Vertical sections of salinity and temperature along Long. 165°E and paralleling the Kurile Islands, summer 1961.
Figure 19. Vertical sections of salinity and temperature along Long. 175°E, summer 1961.
Figure 20. Vertical sections of salinity, temperature and dissolved oxygen along Long. 177°W, summer 1961.
Figure 21. Vertical sections of salinity, temperature and dissolved oxygen along Long. 161°W, summer 1961.
Figure 22. Vertical sections of salinity, temperature and dissolved oxygen along approximately Long. 153°W, summer 1961.
Figure 23. Vertical sections of salinity, temperature and dissolved oxygen along approximately Long. 145°W, summer 1961.
Figure 24. Vertical sections of salinity, temperature and dissolved oxygen along approximately Lat. 50°N, between Long. 158°W and 125°W, summer 1961.
Figure 25. Vertical sections of salinity, temperature and dissolved oxygen between Long. 132°W and the Oregon coast, summer 1961.