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NUMBER 4

HYDROGRAPHIC SECTIONS AND CALCULATED CURRENTS IN THE GULF OF ALASKA

1927 AND 1928

BY

GEORGE F. McEWEN, THOMAS G. THOMPSON, AND RICHARD VAN CLEVE

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FOREWORD

The present is a fourth report by the International Fisheries Commission upon scientific results obtained under the terms of the Convention of 1924, between the United States and Great Britain, for the preservation of the halibut fishery of the Northern Pacific Ocean, including Bering Sea.

It is a technical study of the rate and direction of those currents which affect the distribution of the eggs and larvae of the halibut in the Gulf of Alaska. It has been preceded by Report Number 3, by Thomas G. Thompson and Richard Van Cleve, describing certain of the chemical methods used in obtaining the data here dealt with.

The International Fisheries Commission has had the help of an advisory board of four members: Dr. C. McLean Fraser, Dr. W. A. Clemens, Mr. N. B. Scofield, and the late Prof. John N. Cobb.

The investigations have been carried on by a staff under the direction of William F. Thompson, with headquarters and laboratory at the University of Washington, Seattle, U. S. A.

REPORTS BY THE INTERNATIONAL FISHERIES COMMISSION

1. Report of the International Fisheries Commission appointed under the Northern Pacific Halibut Treaty, by John Pease Babcock, Chairman, and Wm. A. Found, Miller Freeman, and Henry O'Malley, Commissioners. Dominion of Canada, Ottawa, 1928.

   Same. Report of the British Columbia Commissioner of Fisheries for 1928, pp. 58-76. Victoria, 1929.

   Same. Report of United States Commissioner of Fisheries for 1930, Appendix 1. U. S. Bureau of Fisheries Document No. 1073. Washington, 1930.

2. Life History of the Pacific Halibut (1) Marking Experiments, by William F. Thompson and William C. Herrington. Victoria, 1930.

3. Determination of the Chlorinity of Ocean Waters, by Thomas G. Thompson and Richard Van Cleve. In press.

4. Hydrographic Sections and Calculated Currents in the Gulf of Alaska, 1927 and 1928, by George F. McEwen, Thomas G. Thompson, and Richard Van Cleve.

Further reports will bear serial numbers and will be issued separately by the commission.

HYDROGRAPHIC SECTIONS AND CALCULATED CURRENTS IN THE GULF OF ALASKA, 1927 AND 1928

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CONTENTS

INTRODUCTION

The hydrographical work reported in this paper was undertaken by the International Fisheries Commission to ascertain the nature, direction, and velocity of the currents in the Gulf of Alaska. The commission is primarily interested in a study of the halibut, and one phase of the biological study of this species is an investigation of the drift of the pelagic eggs and larvae. These fish spawn on the bottom of the open sea, and their eggs and larvae are therefore at the mercy of any current occurring at the depth in which they float.[1]

[1]The present work was begun by the commission in 1927, when a series of hydrographic stations was made off Yakutat Bay, the best known spawning ground. The following year a more definite and comprehensive program was decided upon. In the execution of this the director had suggestions from Dr. H. C. Bigelow of Harvard University and Dr. G. F. McEwen of Scripps Institution. This program was to compute the currents through chlorinity and temperature data for two years. These were to be followed, or accompanied, as the case might be, by direct current determinations, either by drift bottles and buoys or current meters, phases of the investigation which have not been undertaken as yet.

Accordingly, in 1928, three cross sections were laid from Ocean Cape, Cape Cleare, and Cape Chiniak by the schooner "Dorothy" under supervision of Mr. Van Cleve. The chlorinity of this water and the characteristics of its distribution were determined by Dr. T. G. Thompson with the assistance of Mr. Van Cleve, and from the resultant data, mathematical computations of the currents were made by Dr. McEwen. The following year the sections were again made, but to a greater distance from the coast. The results for 1927 and 1928 are now presented. The work for the year 1929 is still to be reported upon.

Any drift of the eggs and larvae, whether westerly or otherwise, will have an important bearing on the fishery and its regulation. The questions at issue in the fate of these eggs and larvae are first, as to the source of the young supporting the fishing along the British Columbian and Southeastern Alaskan coasts, and second, as to the existence of a drift of the younger stages contrary to that coastwise migration of mature along the Alaska Peninsula which has been indicated by the marking experiments described in Report Number 2. It is plain that, if a great eddy exists in the Gulf of Alaska, eggs spawned on its eastern side may ultimately find lodgement either along the western shores of the Gulf or along the coast to the south, depending upon the rate and direction of drift during the pelagic period.

The investigation of the early life history has therefore been two-fold, first of the currents and second of the distribution of the eggs and larval stages. The latter has been carried on by means of net hauls over the spawning beds and over the Gulf of Alaska, these hauls being so planned as to discover the distance at which the larvae are found from the continental slope, and any increase in this distance with passage of time. The study of the depth at which the various stages float forms a part of the future program, necessary because of the variation in currents at the different levels.—W. F. Thompson.

GEOGRAPHY

The southeastern coast of Alaska presents the shape of a large crescent opening on the Pacific Ocean and including the Gulf of Alaska. The southeastern horn of this crescent comprises the Alexander Archipelago with its innumerable inlets, bays, and mountainous islands, which give the shoreline its rugged and abrupt character.

The mountains of this archipelago might be considered a part of the Coast Range on the eastern side, and a southern extension of the St. Elias Range on the west (Brooks, 1906). However, their separation by deep tidal waterways from the Coast and St. Elias ranges has caused them to be considered as a distinct group.

The soundings on the continental shelf along this section of the coast show it to be of the same rugged character as the land. Often depths of 100 fathoms and 1000 fathoms are found within a few miles of each other. The edge of the continental slope, taken as the 1000 fathom line, is found here from 30 to 50 miles[2] offshore.

The halibut are found along the coast in shallow water, and in some cases, out to the depth of 300 fathoms, equal to 550 meters. None of the banks in this section, however, are noted for spawning.

The character of the coast line north of Cross Sound and the Alexander Archipelago changes to become smooth and unbroken except for Lituya Bay, a T-shaped inlet lying about 30 miles north and west of Cross Sound, and Yakutat Bay, a large funnel-shaped inlet which lies about 90 miles west by north of Lituya Bay and receives the drainage and several glaciers from the St. Elias Mountains. The mountains in the southeastern part, increasing in height from the south to the north, culminate near the coast in the Fairweather group, just north of Cross Sound, some peaks of which are over 15,000 feet. This region and its western extension, including the Chugach Mountains around Prince William Sound, and the Kenai Mountains of the Kenai Peninsula, are the highest of the western part of the continent and contain about nine-tenths of all the glacial ice on the coast. In the region of the Fairweather and St. Elias mountains are found such large glaciers as the Great Plateau Glacier, on the outer slopes of Mt. Fairweather, the Brady Glacier, flowing into Cross Sound, and the great masses of ice found around Glacier Bay. Farther north is found the Malaspina Glacier, the largest of all the glaciers in Alaska and perhaps the continent. This glacier lies on the seaward slopes of the St. Elias Mountains and is about 20 miles long by 65 to 70 miles wide. Only at Icy Bay, 50 miles west of Ocean Cape, does a very small part touch the sea.

The continental shelf here includes the famous Yakutat and W fishing banks, the largest halibut spawning banks now known. The Yakutat Bank lies 50 to 70 miles south and west of Ocean Cape, and the W grounds about 40 miles south

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[2]The mile used in the measurement of distance in this paper is the nautical mile.

by west of Icy Bay. During the spawning season the fish congregate on these banks, in depths varying from 200 meters to 500 meters, to spawn, and it is in the vicinity of these banks that the greatest number of eggs and larvae have been found.

The smooth coast line running westward from Yakutat Bay, interrupted by Icy Bay, is terminated by Kayak Island, which protrudes about 18 miles into the Gulf to form Cape St. Elias. Fifty-seven miles south and west of Cape St. Elias, about midway between it and Cape Cleare, lies Middleton Island, a low sandy island, situated about 10 miles within the 100 fathom line—as shown on the chart—and at the outer edge of a shallow bank lying between Cape St. Elias and Montague Island.

West of Cape St. Elias are Controller Bay and the Copper River Delta, beyond which lies Prince William Sound, where the coast again assumes the rugged and abrupt character typical of all the rest of the southern coast of Alaska except Cook Inlet.

To the north, Prince William Sound is bounded by the Chugach Mountains, from which a large number of glaciers flow to the sea. John Muir, in his discussion of the glaciers of Alaska in "The Alaska-Harriman Expedition," states that there are over eleven glaciers of the first class in this region (Burroughs, Muir, and Grinnell, 1901).

Westward from Prince William Sound the coast turns to the southwest, following the Kenai Peninsula, which forms the eastern boundary of Cook Inlet, the largest enclosed body of water in Alaska. The latter extends 150 miles to the north from its entrance, then turns easterly, continuing for about 30 miles as Turnagain Arm. Here, as mentioned above, in the upper reaches, the shores are low and smooth. From Cook Inlet, westward along the Alaska Peninsula, the shore has the same broken and abrupt character as in Prince William Sound, and usually rises steeply to the Aleutian Range.

To the southwest of the Kenai Peninsula the line of the peninsula is continued by Afognak and Kodiak Islands, which are separated from the mainland by Shelikof Straits. The mountains of these islands, none of which exceed 3000 or 4000 feet in altitude, are said to be an extension of the Kenai Range (Burroughs, Muir, and Grinnell, 1901). Kodiak Island, the largest island in Alaskan waters, though characterized by a comparatively low relief, has a rugged coast.

Eastward of Kodiak and Afognak Islands the continental slope (1000 fathom line) extends from 50 to 100 miles offshore, and includes the famous Portlock and Albatross halibut banks. Halibut are also found in greater or lesser numbers to the westward as far as Japan. Undoubtedly the fish spawn along this entire coast line, but none of these places have been found to be as great spawning centers as the Yakutat and W Banks.

Very little is known about the currents in the Gulf of Alaska. According to the British Columbia Coast Pilot (U. S. Hydrographic Office, 1920), a southeast current has been found to exist from 25 to 30 miles off the southwest coast of

Vancouver Island, more or less throughout the year. It is most marked during the summer and autumn months, when the west or northwest winds prevail. Between this current and the shore along the west coast of Washington and Vancouver Island is a northwest current, the velocity of which varies greatly with the wind, being augmented in southeast or southwest winds and nearly stopped in westerly or northwest winds. The currents off the coast of British Columbia are said to be the result of the combined water of the Kuroshiwo or Japan stream and the eastern drift of the North Pacific, "the former giving it not only strength and volume but high temperature, which it bears with it, and which has a marked influence on the climate of northwest America" (U. S. Hydrographic Office, 1920). The velocity of the inner or northwest current varies from one-half to one and one-half miles per hour.

Evidence of a northwest current is given by the differences noticed in log readings of boats on the western Alaska run. The log reading for the trip west from Cape Spencer to Prince William Sound is invariably less than that for the return trip, and in one case the difference averaged 127 miles for six trips between Cape Flattery and Cape St. Elias. A southwest current has also been reported along the coasts of Hinchinbrooke and Montague Islands and the Kenai Peninsula. From data thus collected a current varying in velocity from zero to one and one-half miles per hour has been estimated. The distance it extends out from shore is not known, but it is thought to be strongest near the 100 fathom line (U. S. Coast and Geodetic Survey, 1925 and 1926).

Thus, though the presence of a westerly surface drift is unquestioned, the extent, variability, depth, and exact location of the drift must be determined to ascertain the extent of its effect on the eggs and larvae of the halibut.

DESCRIPTION OF THE LOCATION OF THE DIFFERENT SECTIONS AND STATIONS

In January, 1927, when this phase of the work was begun by W. F. Thompson and his assistants of the International Fisheries Commission, the Ocean Cape section was selected for a preliminary survey of the hydrographical conditions existing on the halibut banks during the spawning season. This section is shown in Figure 9, being the same as for 1928, but extending only to station 7. It extends on a line from 4 miles to 64 miles south of Ocean Cape Light, passing just eastward of the Yakutat Banks.

The following year three sections were selected in order to determine the extent of the currents in the Gulf of Alaska. Samples of water were collected in January, just about the middle of the spawning season, at a time when newly spawned eggs and early larvae are found. The location and the relation of the several sections are shown in Figure 9, and are designated as Ocean Cape section, Cape Cleare section, and Cape Chiniak section. The positions of these sections were considered the most strategic.

The Ocean Cape section for 1928 was a repetition of the 1927 section and was also made in January, but it extended 10 miles farther out into the Gulf. The location of the stations in the section is correct to less than 3 miles to either side of the line of the section. Greater accuracy was impossible because of weather and the lack of accurate soundings and charts. This explains the difference between the soundings at the 64 mile station in the two different years (Tables 2 and 5).

The Cape Cleare section, the data for which were collected January 21, 1928, ran from 4 miles to 54 miles southeast of Cape Cleare, with stations at 10 mile intervals.

The samples from the Cape Chiniak section were collected January 30, 1928. The stations extended on a line 5 miles to 55 miles east-southeast of Cape Chiniak.

The lines of all three of the sections were continued to points just beyond the edge of the continental shelf.

In 1929 sections were studied in the same localities as in 1928 ,but they were extended out to the middle of the Gulf in order to get a more complete knowledge of the currents of the whole area. The results of this work will appear in a later paper.

COLLECTION OF SAMPLES

The samples were collected with water bottles of the Greene-Bigelow type (Hawley, 1928), and the temperatures were determined with the Richter reversing thermometers of Negretti and Zambra. All thermometers used were calibrated by Professor F. W. Osborne of the Department of Physics, University of Washington.

Six samples were collected simultaneously from as many different depths. As soon as a sample was brought aboard, it was stored in the ordinary citrate bottle, the latter was tagged, and all data concerning the sample recorded in the log-book before the next water bottle was brought on deck. The bottles were stored in wooden cases to prevent breakage and to facilitate convenience in handling until they were analyzed in the laboratories of the Department of Chemistry at the University of Washington.

METHODS OF ANALYSIS AND COMPUTATION

After a study of the various methods for the determination of chlorinity (Thompson and Van Cleve, 1930), that outlined by Thompson (1928) was used. The silver nitrate solutions were standardized with both the normal water of the Hydrographic Laboratories of Copenhagen and with pure solutions of sodium chloride. All of the determinations were carried out at a temperature of 20°.

The chlorinities were determined independently by two of the authors and an accuracy of 0.015 per mille on all the samples was obtained.

The results obtained from the various samples of water collected at the several sections are shown in the tables.

In Tables 2, 5, 8, and 11, showing the fundamental data, the significance of the various columns is as follows:

Column 1. Station number.
2. Depth of water in meters.
3. Depth at which samples were taken.
4. Temperature.
5. Chlorinity.
6. $\sigma_{s,t,o}$ = (Density −1) 10^3, where the density is computed from the temperature and chlorinity but is not corrected for the pressure, p.
7. V_1 equals the last three figures of the specific volume *in situ*.
8. Dynamic depth.
9. Location of station.

The computations of $\sigma_{s,t,o,}$ at atmospheric pressure (referred to as zero pressure) which corresponds to the surface, were made by means of a detailed tabulation based upon Knudsen's Hydrographical Tables (1901). Methods outlined by Hesselberg and Sverdrup (1915) and Smith (1926) derived from the fundamental Bjerknes theory (Bjerknes and Sandström, 1910) were used in computing specific volumes *in situ*, dynamic depths, and relative velocities.

A brief explanation of these dynamic computations follows. While computations of ocean currents due to differences in specific gravity are based upon fundamental principles of mechanics, the Archimedian laws of hydrostatics in particular, practical applications are greatly facilitated by transforming these principles into new and more developed forms especially devised for the purpose.

The fundamental work of V. Bjerknes in physical hydrodynamics (a theory of fluid motion in which density or its reciprocal, specific volume, may depend not only upon pressure but upon any number of other variables, temperature, humidity, salinity, etc.) included such a development upon which has been based one of the most successful and progressive attempts to apply mathematics to problems of meteorology and oceanography. His students and colleagues, Sandström, Ekman, Helland-Hansen, Nansen, and others interested in physical oceanography, have evolved from his basic contribution practicable methods for computing the direction and velocity of ocean currents from temperatures and chlorinities observed at a suitable number of known depths and stations.

The simplest and most commonly used special case of the Bjerknes circulation theorem assumes a current fully developed caused by the distribution of pressure corresponding to the observed distribution of temperature and salinity. The deflecting force, due to the earth's rotation, is proportional to the velocity of the water, is directed to the right of this velocity in the Northern Hemisphere, and balances the pressure gradient. His circulation theorem expressing this relation then reduces to the equation:

$$C_n - C_b = \frac{.0195}{2w \sin \phi \; 10^5} \; \frac{\triangle_{nb} \; 10^5}{L} \quad \text{knots per hour}$$

where $C_n - C_b$ is the velocity relative to the bottom, w equals the angular velocity of the earth, L is the horizontal distance in kilometers between stations, ϕ is the latitude. $\triangle_{nb}$ is the difference in the height of the water above the lowest level, common to two adjacent stations. This difference in height is due to differences in specific gravity at the two stations. The coefficient $\frac{.0195}{2w \sin \phi \; 10^5}$ varies only with the latitude and can be read off directly from a table of corresponding values.

From very careful laboratory experiments by Knudsen, Ekman, and others on the physical properties of sea water, accurate tables have been prepared indicating the relation of density and its reciprocal specific volume V to temperature T, salinity S, and pressure p. Combining these results with the fundamental equation of hydrostatics that the pressure due to a column of water is proportional to the depth h, its density, and the acceleration of gravity g, a convenient plan has been devised for computing the specific volume *in situ* and the dynamic depth, $D = pV$, from temperature and salinity observations. The difference between values of D at two stations, and the distance between the stations, determines the pressure gradient.

The computation of specific volumes V and dynamic depth D are presented in detail (Table 1) for station 6 in the 1927 Ocean Cape section, as an illustrative example. The symbols used in these dynamic computations are defined in the following table, but the fundamental reference tables (McEwen, 1929) based upon the physical properties of sea water and the law of hydrostatic pressure are not reproduced in this paper.

T = temperature Centigrade.

Cl = Chlorinity, per mille Cl.

S = Salinity, per mille S.

$P_{s,t,o}$ = specific gravity at zero pressure.

$\sigma_{s,t,o} = (P_{s,t,o} - 1) \; 10^3$, obtained from Tables 2, 3, and 4 (McEwen, 1929) and entered in column 6.

Column 5 = interpolation corrections to basic value taken from Table 5 (McEwen, 1929).

Column 7 $= \frac{\sigma_{s,t,o} \; 10^{-3}}{1 + \sigma_{s,t,o} \; 10^{-3}} 10^5 = (1 - V_{s,t}) \; 10^5$ obtained from Table 5 (McEwen, 1929).

$V_{s,t}$ = specific volume at zero pressure.

$V_{s,t,p} = 1 - \frac{\sigma_{s,t,o} \; 10^{-3}}{1 + \sigma_{s,t,o} \; 10^{-3}} - \delta_p - \delta_{t,p} - \delta_{s,p}$ = specific volume at pressure p.

δ_p = depth or pressure correction to specific volume for "standard water," corresponding to $T = 0$, $S = 35$, $Cl = 19.375$ per mille from Table 6 (McEwen, 1929).

$\delta_{t,p}$ = temperature-pressure correction to specific volume, from Table 6 (McEwen, 1929).

$\delta_{s,p}$ = salinity-pressure correction to specific volume, from Table 7 (McEwen, 1929).

δ, Column 12 = (total correction to add to $V_{s,t,o}$) $= \delta_p + \delta_{t,p} + \delta_{s,p}$

$$(1 - V_{s,t,p})\ 10^5 = (1 - V_{s,t,o})\ 10^5 - 10^5\delta = \frac{\sigma 10^{-3}}{1 + \sigma 10^{-3}}\ 10^5 - 10^5\delta.$$

Column 13 = means of successive pairs of values in Column 12.

Column 14 = Δ_p = depth difference in meters corresponding to the pair of values of Column 12, whose mean is entered in Column 13.

Column 16 = $10^5 \times$ the correction to subtract from Column 1 to obtain the depth in dynamic meters D.

Column 17 = D = depth in dynamic meters.

Column 18 = 10^5 — Column 12 = $10^5 \times$ the specific volume.

The method of finding the numerator Δ_{nb} in the velocity equation will be illustrated by reference to Table 3 (a tabulation of the differences in dynamic depths between adjacent stations in the Ocean Cape section for 1927). The first column under 7-6 is the result of subtracting D for station 6 from the corresponding value for station 7 and disregarding the decimal point. This is equivalent to multiplying the difference by 10^5. These differences would be used if it were desired to compute velocities relative to the surface. To refer the velocities to the bottom subtract each difference from the last one (–604 in this case), thus obtaining the second column under 7-6, which is the value $10^5 \Delta_{nb}$. Negative and positive values indicate, respectively, velocities away from and toward the observer facing the section, the coast being on the right. The coefficient $\frac{.0195}{2w \sin \phi\ 10^5 L} = K$ is read off from fundamental tables, an average value of the latitude ϕ being used. For this section, $K = .0000804$, which is entered in Table 4, a tabulation of the velocities in miles per hour.

In the absence of other information, the velocity is assumed to be zero at the greatest depth at which observations are available at the same level. The component of the velocity perpendicular to the sections is estimated in this way. Therefore, a low estimate of the current is usually obtained by this method. Furthermore, the more nearly the sections are at right angles to the current the smaller is the error caused by neglecting friction, if the direction of the flow departs but little from the average. The current diagrams (Figures 2, 4, 6, and 8), were obtained by graphical interpolation of the tabulated average values.

RESULTS AND DISCUSSION

The results obtained from the samples of water collected at the various stations in the several sections are given in the tables below. From a study of these data the following arbitrary classifications of the waters were made:

1. COASTAL WATERS: Waters which composed the surface layer and had chlorinities less than 18 per mille and values of $\sigma_{s,t,o}$ less than 25.50. The temperatures were generally less than 5°. In the outer portion of the Ocean Cape section this water reached a temperature as high as 6°.

2. INTERMEDIATE WATER: This water composed the strata underlying the coastal water and had chlorinities which varied between 18.00 per mille and 18.70 per mille. This gave values of $\sigma_{s,t,o}$ which ranged from 25.50 to 25.70 and from 26.70 to 26.80. The temperature of the intermediate water was between 6.0° and 6.4° at Ocean Cape, beyond the continental shelf, and gradually decreased as the coast was approached. At Cape Cleare and Cape Chiniak the intermediate water occurred only over the outer portion of the banks. In the former section this water had a temperature between 5.5° and 6.0°, while in the latter section it varied from 5.8°, beyond the continental shelf, to 4.3° in toward the coast.

3. OCEAN WATER: This type of water had a chlorinity greater than 18.70 per mille and $\sigma_{s,t,o}$ exceeded 26.80. The upper strata of the ocean water had a temperature generally lower than that of the intermediate water and higher than that of the coastal water.

It will be observed from this arbitrary classification of the waters that marked uniformity in chlorinity and temperature was observed. Sandström (1919) and Bigelow (1927), for example, in their investigations of the waters off the Atlantic Coast, found far greater variations in temperature and chlorinity.

OCEAN CAPE SECTION—1927 AND 1928

The fundamental data for the Ocean Cape section, 1927, are given in Table 2, and illustrated in Figure 1. The coastal water was found at the bottom of stations 1, 3, and 4, but beyond this point it lay over the intermediate water. It was thinnest directly over the edge of the continental slope and then increased in thickness out to the end of the section. The intermediate water extended in as far as station 4, and also appeared in the gully at station 2. It was fairly uniform in thickness, becoming somewhat constricted at the outer end of the section. The ocean water occurred at a depth of 180 meters and covered about 5 miles of the outer edge of the bank.

The fundamental data for the 1928 section are given in Table 5 and illustrated in Figure 3. The coastal water averaged about 100 meters in thickness out to station 7, and beyond this point it rapidly merged with the intermediate water. With the exception of station 1, the intermediate water covered the entire bank, and at the edge of the continental slope it showed a marked tendency to rise toward the surface. The ocean water reached only to the edge of the continental slope and occurred at a depth that varied from 275 meters, at station 7, to 200 meters at the end of the section.

A comparison of the data for the two years shows that the temperatures for 1927 were higher in the coastal and intermediate waters, but were practically the same for the ocean water. The isotherms for 1927 showed a cold layer of water extending over the surface outward from the coast. Below this were the warmer strata of the denser coastal water and the intermediate water. The isothermal surfaces for 1927 were quite regular. Those for the coastal water in 1928, while showing the colder upper layer over the warmer strata, were not so uniform. In general, however, the temperature variations in the section for both years were less than 2° in the coastal and intermediate water.

The results of the dynamical computations are given in Tables 3, 4, 6, and 7, and are illustrated in Figures 2 and 4. The currents showed a marked irregularity throughout the section, but the general trend was westerly. At several stations easterly currents were observed, a variation in direction that has been previously noted (U. S. Hydrographic Office, 1920; U. S. Coast and Geodetic Survey, 1925 and 1926). The westward velocity of the current was greatest off the continental slope, where a speed relative to the bottom of 0.4 miles per hour was calculated in the upper strata for 1928.

CAPE CLEARE SECTION—1928

The fundamental data for the Cape Cleare section, collected in 1928, are given in Table 8 and illustrated in Figure 5. The coastal waters covered the shallower portion of the bank for about 30 miles from the coast. At this point the coastal water had a depth of 170 meters, but beyond it the waters tended to become more and more shallow, and at the end of the section the layer was only 100 meters in thickness. The intermediate water lay over the outer part of the bank between points from 30 and 39 miles off the coast. This stratum had a thickness of 190 to 160 meters and was inclined upward and outward toward the surface. The ocean water extended in about 5 miles over the edge of the bank, where it was 295 meters below the surface, but at the end of the section it lay at a depth of 290 meters.

With the exception of the water directly over the intermediate water, the coastal layer had a temperature below 5.5°. The temperature of the intermediate water was between 5.6° and 6.1°, while the upper strata of the ocean water had a temperature approximating 5.5°. In general the temperatures of the entire section were very uniform, the maximum variation was only 2.9°, but they were slightly lower than those observed in the Ocean Cape section.

The chlorinity of the coastal waters off Cape Cleare were a little less than those off Ocean Cape, and the relative volume of the layer was considerably greater.

The results of the dynamical treatment of the data in Table 8 are given in Tables 9 and 10, and show a very marked variation in velocity and direction of the current, analogous, in many ways, to that observed at Ocean Cape. The highest westward velocity occurred off the edge of the bank, as shown in Figure 6.

CAPE CHINIAK SECTION—1928

The fundamental data for the Cape Chiniak section are given in Table 11, and illustrated in Figure 7. The water over the bank was very uniform, the temperature varying only from 3.7° to 4.1° at the three inner stations. The mean temperatures of the water layers were lower than that observed in the sections discussed above (Table 14). As the edge of the bank was approached there was a very noticeable increase in the temperature of both the surface and sub-surface layers, and the highest temperatures occurred at 100 and 200 meters in the outermost stations. The temperature of the ocean water was much the same as that at Cape Cleare, but was a little lower than that of Ocean Cape.

The coastal water covered most of the bank. At the edge of the continental slope there was a decided upwelling of the denser water, but the lighter coastal water again occurred in the stations beyond the continental slope. The intermediate water, except for the upwelling, showed the same general tendencies as that observed at Cape Cleare.

The results of the dynamical treatment of the data in Table 11 are shown in Tables 12 and 13, and illustrated in Figure 8. Very little movement of the water is shown over the bank. An eastward current was present at the point of upwelling, but further out in the section there was a most decided westward current reaching a velocity of over 0.8 miles per hour. This latter current had about twice the velocity of any current observed in the other sections.

In Table 14 are given the average chlorinities, temperatures, and densities of the waters from the different depths for the three sections. It will be noticed that the temperatures became lower as one proceeded to the westward from Ocean Cape, while the chlorinities are found to have been highest off Cape Chiniak and lowest off Cape Cleare. The variation in chlorinity may be explained by the position of the various sections relative to fresh water outlets.

SUMMARY

1. One section, with stations at ten mile intervals, south of Ocean Cape in the Gulf of Alaska, was studied in 1927. Three similar sections were studied in 1928 in the Gulf of Alaska; the Ocean Cape, Cape Cleare, and Cape Chiniak sections.

2. The water was classified into three arbitrary types, i.e., coastal water with a chlorinity less than 18 per mille and a value of $\sigma_{s,t,o}$ less than 25.50, intermediate water underlying the coastal waters and having a chlorinity between 18.00

per mille and 18.50 per mille and a value of $\sigma_{s,t,o}$ between 25.50 and 26.40, and ocean water with a chlorinity greater than 18.50 per mille and a value of $\sigma_{s,t,o}$ greater than 26.40.

3. It was found that in all three sections there was a cold surface layer lying over a deeper warmer stratum, the warmest part of which was at the outer ends of the sections.

4. The temperature and chlorinity data were treated hydro-dynamically according to Bjerknes' theory.

5. The currents, though very irregular, showed a general trend toward the west in all three sections, with the greatest irregularity in the waters overlying the banks, and in all cases a very decided westward current just over the edge of the continental slope.

TABLE 1.—*Computation of Dynamic Depth and Specific Volume from Observations of the Waters of Station No. 6. Ocean Cape Section, 1927.*

(1) Depth in Meters	(2) Temperature	(3) Cl o/oo	(4) S o/oo	(5) $\Delta\sigma$ for $\{\Delta t, \Delta s\}$	(6) Base Value	(6) $\sigma_{s,t,o}$ Corrected Value	(6) $\Delta\sigma$	(7) $\frac{10^5(\sigma_{s,t,o})10^{-3}}{1+(\sigma_{s,t,o})10^{-3}}$	(8) $-10^5\delta_p$	(9) $-10^5\delta_{t,p}$	(10) $-10^5\delta_{s,p}$	(11) $-10^5\delta=$ (8)+(9)+(10)	(12) $(1-V_{s,t,p})10^5=$ (7)+(11)	(13) Means of pairs of values in (12)	(14) $\Delta P=$differences of successive values in (1)	(15) (13)×(14)	(16) Successive summation of values of (15)	(17) (1) − 10^{-5}(16) $=D$	(18) $10^5-(12)=10^5V_{s,t,p}$
0	6.00	17.82	32.20	0 .158	(25.208)	25.366	.788	2474	0	0	0	0	2474				0	0	97526
														2474.5	18.2	45035.9			
18.2	6.68	17.83	32.21	−.010 .165	(25.133)	25.288	.786	2467	8	0	0	8	2475				45035.9	17.74964	97525
														2514.5	73.2	184061.4			
91.4	7.19	18.24	32.95	−.013 .745	(25.068)	25.800	.785	2515	40	−1	0	39	2554				229097.3	89.10903	97446
														2576	45.8	117980.8			
109.7																			
137.2	6.58	18.35	33.15	−.010 .118	(25.933)	26.041	.787	2538	62	−2	0	60	2598				347078.1	133.72922	97402
														2623	45.7	119871.1			
182.9	6.10	18.54	33.49	.000 .386	(25.984)	26.370	.790	2569	82	−3	0	79	2648				466949.2	178.23051	97352
														2666	36.6	97575.6			
219.5	5.70	18.64	33.68	.000 .538	(26.033)	26.571	.792	2588	99	−3	0	96	2684				564524.8	213.85475	97316

TABLE 2.—*Hydrographical data from the waters of the Gulf of Alaska off Ocean Cape, January 30, 1927.*

Station	Depth in Meters		Temp. °C	Chlor. o/oo	$\sigma s,t,o$	V_1	Dynamic Depth	Location
	Bottom	Sample						
1	89	0	5.95	17.72	25.22	540	0	4 mi S of Ocean Cape.
		18.2					(17.75119)	59° 28′ 15″ N.
		27.4	6.22	17.74	25.22	528	26.72432	139° 54′ 30″ W.
		45.7					(44.57039)	
		64.0	6.25	17.75	25.23	511	62.41645	
2	164	0	5.70	17.74	25.28	534	0	14 mi S of Ocean Cape.
		18.2	5.35	17.77	25.35	518	17.74973	59° 19′ 40″ N.
		27.4					(26.72001)	140° 03′ 50″ W.
		45.7	6.50	17.99	25.54	.488	44.56306	
		64.0					(62.40382)	
		91.4	6.50	17.82	25.30	493	89.11622	
		109.7					(106.94902)	
		137.2					(133.74695)	
		155.4	6.70	18.30	25.96	401	151.48230	
3	124	0	6.00	17.84	25.40	524	0	24 mi S of Ocean Cape.
		18.2	5.50	17.85	25.46	509	17.74800	59° 10′ 40″ N.
		27.4					(26.71887)	140° 13′ 30″ W.
		45.7	6.54	17.83	25.31	510	44.56311	
		64.0					(62.40525)	
		91.4	6.87	17.91	25.37	486	89.11970	
		109.7	4.82	17.89	25.60	458	106.95708	
		137.2					(133.755)	
4	146	0	6.00	17.73	25.24	539	0	34 mi S of Ocean Cape.
		18.2	6.32	17.78	25.27	530	17.75128	59° 02′ 10″ N.
		27.4					(26.72220)	140° 22′ 50″ W.
		45.7					(44.56653)	
		64.0					(62.41086)	
		91.4	6.75	17.86	25.33	490	89.12860	
		109.7					(106.96625)	
		137.2	6.98	17.98	25.46	457	133.77146	
5	183	0	6.09	17.78	25.30	533	0	44 mi S of Ocean Cape.
		18.2	5.85	17.83	25.39	516	17.74946	58° 53′ 20″ N.
		27.4					(26.72065)	140° 32′ 00″ W.
		45.7	6.75	17.85	25.32	510	44.56554	
		64.0					(62.40621)	
		91.4	7.05	18.06	25.58	468	89.11801	
		109.7					(106.94751)	
		137.2	5.93	18.38	26.18	390	133.74049	
6	228	0	6.00	17.82	25.36	526	0	54 mi S of Ocean Cape.
		18.2	6.68	17.83	25.28	525	17.74964	58° 44′ 30″ N.
		27.4					(26.71831)	140° 41′ 30″ W.
		45.7					(44.55815)	
		64.0					(62.39800)	
		91.4	7.19	18.24	25.82	446	89.10903	
		109.7					(106.93762)	
		137.2	6.58	18.35	26.04	402	133.72922	
		155.4					(151.45183)	
		182.0					(177.35411)	
		182.9	6.10	18.54	26.37	352	178.23051	
		219.5	5.70	18.64	26.57	316	213.85475	
7	1645	0				526	0	64 mi S of Ocean Cape.
	NB	18.2	6.60	17.88	25.37	518	17.74900	58° 35′ 30″ N.
		27.4					(26.719598)	140° 50′ 20″ W.
		45.7	6.60	17.95	25.48	495	44.56329	
		64.0					(62.40232)	
		91.4	6.62	18.03	25.59	467	89.11211	
		109.7					(106.93676)	
		137.2					(133.72245)	
		155.4					(151.44970)	
		182.0	6.05	18.63	26.51	338	177.35877	
		182.9					(178.234528)	
		219.5					(213.84871)	
		274.3	5.30	18.73	26.75	275	267.17267	
		365.8	4.50	18.74	26.84	224	356.15596	
		548.5	4.00	18.87	27.09	120	533.68921	
		914.4	3.42	19.00	27.33	938	888.71832	
		1097.3	3.25	18.96	27.29	861	1065.9475	

TABLE 3.—*Tabulation of* $10^5\triangle_n$ *and* $10^5\triangle_{nb}$, *dynamic depth differences for stations 7-6, etc., in the Ocean Cape Section, 1927.*

Depth in Meters	STATION											
	7 — 6		6 — 5		5 — 4		4 — 3		3 — 2		2 — 1	
0	0	−604	0	−1127	0	−3097	0	1646	0	805	0	−1263
18.2	−64	−540	18	−1145	−182	−2915	328	1318	−173	978	−146	−1117
27.4	129	−733	−234	−893	−155	−2942	333	1313	−114	919	−431	−832
45.7	514	−1118	−739	−388	−99	−2998	342	1304	5	800	−733	−530
64.0	432	−1036	−821	−306	−465	−2632	561	1085	143	662	−1263	0
91.4	308	−912	−898	−229	−1059	−2038	890	756	348	457		
107.9	−86	−518	−989	−138	−1874	−1223	917	729	806	−1		
137.2	−677	73	−1127	0	−3097	0	1646	0	805	0		
155.4	−213	−391										
182.0	466	−1070										
182.9	−402	−202										
219.5	−604	0										

TABLE 4.—*Tabulation of computed average velocities in miles per hour relative to the bottom between stations 7-6, etc., perpendicular to the Ocean Cape Section, 1927.*

Depth in Meters	STATION					
	7 — 6	6 — 5	5 — 4	4 — 3	3 — 2	2 — 1
	K= .0000804	.0000804	.0000804	.0000804	.0000804	.0000804
0	−.0486	−.0906	−.249	.1325	.0647	−.1015
18.2	−.0434	−.0921	−.2344	.1060	.0786	−.0898
27.4	−.0589	−.0718	−.2365	.1056	.0739	−.0669
45.7	−.0899	−.0312	−.2410	.1048	.0643	−.0426
64.0	−.0833	−.0246	−.2116	.0872	.0532	
91.4	−.0733	−.0184	−.1639	.0608	.0367	
109.7	−.0416	−.0111	−.0983	.0586	−.00001	
137.2	.0059	0	0	0		
155.4	−.0314					
182.0	−.0860					
182.9	−.0162					
219.5	0					

TABLE 5.—*Hydrographical data from the waters of the Gulf of Alaska off Ocean Cape, January 13, 1928.*

Station	Depth in Meters: Bottom	Depth in Meters: Sample	Temp. °C	Chlor. o/oo	$\sigma_{s,t,o}$	V_1	Dynamic Depth	Location
1	82	0	4.8	17.10	24.47	612	0	4 mi S of Ocean Cape.
		25	5.3	17.68	25.24	526	24.39213	59° 28′ 15″N.
		50	5.2	17.68	25.26	513	48.77199	139° 54′ 30″ W.
2	164	0	5.0	17.75	25.40	525	0	14 mi S of Ocean Cape.
		25	5.4	17.77	25.37	516	24.38012	59° 19′ 40″ N.
		50	5.7	17.81	25.40	502	48.75737	140° 03′ 50″ W.
		100	5.6	17.96	25.61	459	97.49762	
		150	5.3	18.41	26.28	372	146.20537	
3	122	0	5.6	17.83	25.42	521	0	24 mi S of Ocean Cape
		25	5.5	17.84	25.45	507	24.37850	59° 10′ 40″ N.
		50	5.4	17.84	25.46	494	48.75363	140° 13′ 30″ W.
		100	5.9	18.01	25.63	456	97.49113	
4	137	0	5.3	17.79	25.39	523	0	34 mi S of Ocean Cape.
		25	5.5	17.79	25.37	514	24.37962	59° 02′ 10″ N.
		50	5.4	17.76	25.35	505	48.75700	140° 22′ 50″ W.
		100	6.1	17.99	25.59	461	97.49850	
5	179	0	5.7	17.81	25.38	524	0	44 mi S of Ocean Cape.
		25	5.5	17.80	25.39	513	24.37963	58° 53′ 20″ N.
		50	5.4	17.79	25.39	501	48.75638	140° 32′ 00″ W.
		100	6.4	17.97	25.53	466	97.49813	
		150	6.4	18.17	25.82	417	146.21888	
6	197	0	5.8	17.89	25.49	515	0	54 mi S of Ocean Cape.
		25	5.9	17.91	25.50	502	24.37712	58° 44′ 30″ N.
		50	6.0	17.96	25.56	486	48.75062	140° 41′ 30″ W.
		100	6.2	18.04	25.66	455	97.48581	
		150				(413)	(146.20287)	
		175	6.4	18.34	26.03	383	170.55243	
7	274	0	6.0	17.93	25.52	512	0	64 mi S of Ocean Cape.
		25	5.9	17.91	25.50	502	24.37675	58° 35′ 30″ N.
		50	5.9	17.94	25.54	487	48.75038	140° 50′ 20″ W.
		100	5.8	18.00	25.64	456	97.48613	
		150				(414)	(146.20363)	
		175				(382)	(170.55319)	
		200	6.1	18.47	26.26	352	194.89500	
8	1645 NB	0	6.0	18.00	25.62	502	0	74 mi S of Ocean Cape.
		25	5.4	17.99	25.66	486	24.37350	58° 26′ 35″ N.
		50	5.5	18.02	25.71	470	48.74300	141° 00′ 00″ W.
		100	6.5	18.20	25.84	437	97.46975	
		150				(388)	(146.17600)	
		175				(353)	(170.51869)	
		200	5.8	18.70	26.64	318	194.85263	
		300	5.0	18.76	26.82	257	292.14013	
		400	4.4	18.83	26.99	195	389.36612	
		500	4.2	18.83	27.02	149	486.53813	
		600	4.0	18.87	27.09	100	583.66263	
		700	3.9	18.88	27.11	054	680.73963	
		800	3.6	18.94	27.22	999	777.76613	
		900	3.5	18.95	27.25	953	874.74213	
		1000				(935)	(971.68613)	

TABLE 6.—*Tabulation of* $10^5\triangle_n$ *and* $10^5\triangle_{nb}$, *dynamic depth differences for stations 8-7, etc., in the Ocean Cape Section, 1928.*

Depth in Meters	STATION 8—7	7—6	6—5	5—4	4—3	3—2	2—1
0	0 −4237	0 76	0 −1601	0 −37	0 737	0 −649	0 −1462
25	−325 −3912	−37 113	−251 −1350	1 −38	112 625	−162 −487	−1201 −261
50	−738 −3499	−24 100	−576 −1025	−62 25	337 400	−374 −275	−1462 0
100	−1638 −2599	256 −180	−1232 −369	−37 0	737 0	−649 0	
150	−2763 −1474	76 0	−1601 0				
175	−3450 −787	76 0					
200	−4237 0						

TABLE 7.— *Tabulation of computed average velocities in miles per hour relative to the bottom between stations 8-7, etc., perpendicular to the Ocean Cape Section, 1928.*

Depth in Meters	STATION						
	8 — 7	7 — 6	6 — 5	5 — 4	4 — 3	3 — 2	2 — 1
	K= .000097	.000097	.000097	.000097	.000097	.000097	.000097
0	–.411	.008	–.155	–.0036	.071	–.063	–.142
25	–.379	.011	–.131	–.0037	.061	–.047	–.025
50	–.339	.010	–.099	.0024	.039	–.027	0
100	–.252	–.017	–.036	0	0	0	
150	–.143	0	0				
175	–.076						
200	0						

TABLE 8.—*Hydrographical data from the waters of the Gulf of Alaska off Cape Cleare, January 21, 1928.*

Station	Depth in Meters		Temp. °C	Chlor. o/oo	$\sigma_{s,t,o}$	V_1	Dynamic Depth	Location
	Bottom	Sample						
101	55	0	4.7	17.61	25.19	540	0	4 mi SE of Cape Cleare.
		25	4.5	17.63	25.25	525	24.38313	59° 43′ 00″ N.
		50	4.5	17.65	25.28	510	48.76250	147° 53′ 00″ W.
102	122	0	4.8	17.69	25.31	530	0	14 mi SE of Cape Cleare.
		25	4.8	17.70	25.33	519	24.38113	59° 33′ 30″ N.
		50	4.9	17.70	25.32	508	48.75938	147° 46′ 45″ W.
		100	5.1	17.77	25.39	480	97.50613	
103	121	0	4.5	17.61	25.23	538	0	24 mi SE of Cape Cleare.
		25	4.4	17.64	25.29	522	24.38250	59° 24′ 10″ N.
		50	4.5	17.66	25.31	508	48.76125	147° 40′ 30″ W.
		100	4.8	17.73	25.37	482	97.50875	
104	174	0	4.7	17.65	25.27	535	0	34 mi SE of Cape Cleare.
		25	4.7	17.67	25.30	521	24.38200	59° 14′ 50″ N.
		50	4.9	17.76	25.41	500	48.75963	147° 34′ 30″ W.
		100	5.6	17.92	25.55	464	97.50063	
		150	5.6	18.01	25.68	429	146.21388	
105	347	0	5.1	17.73	25.34	528	0	44 mi SE of Cape Cleare.
		25	5.2	17.74	25.34	517	24.38063	59° 05′ 15″ N.
		50	5.2	17.79	25.41	499	48.75763	147° 28′ 20″ W.
		100	5.6	17.87	25.48	471	97.50013	
		150				(395)	(146.21663)	
		200	6.1	18.42	26.19	359	194.90513	
		300	5.2	18.74	26.77	261	292.21513	
106	1371 NB	0	5.3	17.87	25.51	511	0	54 mi SE of Cape Cleare.
		25	5.0	17.84	25.51	502	24.37663	58° 55′ 30″ N.
		50	5.2	17.87	25.52	487	48.75025	147° 22′ 20″ W.
		100	5.2	17.99	25.69	450	97.48450	
		150				(389)	(146.19425)	
		200	5.5	18.56	26.47	332	194.87450	
		300	4.6	18.72	26.82	258	292.16950	
		400	4.2	18.75	26.90	204	389.40050	
		500	4.0	18.77	26.95	155	486.58000	
		600	3.9	18.87	27.10	099	583.70700	
		700	3.7	18.90	27.15	050	680.78150	
		800	3.6	18.94	27.22	999	777.80600	
		900	3.4	18.94	27.24	952	874.78150	
		1000	3.2	18.96	27.29	904	971.70950	

TABLE 9.—*Tabulation of* $10^5\Delta_n$ *and* $10^5\Delta_{nb}$, *dynamic depth differences for stations 106-105, etc., in Cape Cleare Section.*

Depth in Meters	STATION				
	106-105	105-104	104-103	103-102	102-101
0	0 −4563	0 275	0 −812	0 262	0 −312
25	−400 −4163	−137 412	−50 −762	137 125	−200 −112
50	−738 −3825	−200 475	−162 −650	187 75	−312 0
100	−1563 −3000	−50 325	−812 0	262 0	
150	−2238 −2325	275 0			
200	−3063 −1500				
300	−4563 0				

TABLE 10.—*Tabulation of computed average velocities in miles per hour relative to the bottom between stations 106-105 etc., perpendicular to the Cape Cleare Section.*

Depth in Meters	STATION				
	106-105	105-104	104-103	103-102	102-101
	K= .000097	.000097	.000097	.000097	.000097
0	−.443	.027	−.079	.025	−.030
25	−.404	.040	−.074	.012	−.011
50	−.371	.046	−.063	.007	0
100	−.291	.032	0	0	
150	−.226	0			
200	−.145				
300	0				

TABLE 11.—*Hydrographical data from the waters of the Gulf of Alaska off Cape Chiniak, January 30, 1928.*

Station	Depth in Meters: Bottom	Depth in Meters: Sample	Temp. °C	Chlor. o/oo	$\sigma_{s,t,o}$	V_1	Dynamic Depth	Location
201	73	0	4.1	17.92	25.70	492	0	5 mi ESE of Cape
		25	3.9	17.91	25.72	481	24.37163	Chiniak.
		50	4.0	17.91	25.70	470	48.74050	57° 33′ 30″ N.
								152° 03′ 0″ W.
202	64	0	4.0	17.90	25.70	495	0	15 mi ESE of Cape
		25	3.7	17.87	25.68	485	24.37250	Chiniak.
		50	3.7	17.87	25.68	473	48.74225	57° 26′ 15″ N.
								151° 49′ 40″ W.
203	67	0	4.0	17.88	25.66	498	0	25 mi ESE of Cape
		25	3.7	17.91	25.74	479	24.37213	Chiniak.
		50	3.7	17.88	25.69	472	48.74100	57° 19′ 25″ N.
								151° 36′ 30″ W.
204	124	0	4.7	18.02	25.80	485	0	35 mi ESE of Cape
		25	4.3	18.02	25.84	470	24.36937	Chiniak.
		50	4.5	18.03	25.83	459	48.73549	57° 12′ 15″ N.
		100	4.7	18.06	25.86	436	97.45924	151° 23′ 30″ W.
205	548	0	5.0	17.92	25.62	502	0	45 mi ESE of Cape
		25	4.7	17.95	25.70	484	24.37325	Chiniak.
		50	4.7	17.95	25.70	472	48.74275	57° 05′ 30″ N.
		100	5.5	18.12	25.85	436	97.46975	151° 10′ 40″ W.
		200	5.4	18.60	26.54	326	194.85075	
		300	4.3	18.73	26.85	252	292.13975	
		400	4.2	18.79	26.96	198	389.36475	
		500	4.0	18.83	27.04	147	486.53725	
206	1371 NB	0	4.8	17.98	25.73	492	0	55 mi ESE of Cape
		25	4.4	18.01	25.81	473	24.37063	Chiniak.
		50	4.4	18.06	25.89	453	48.73638	56° 58′ 10″ N.
		100	5.8	18.49	26.33	389	97.44688	150° 57′ 35″ W.
		200	4.7	18.73	26.82	300	194.79138	
		300	4.35	18.74	26.86	251	292.06688	
		400	4.0	18.83	27.04	191	389.28788	
		500	4.35	18.85	27.02	147	486.45688	
		600	3.6	18.87	27.12	096	583.57838	
		700	3.6	18.92	27.20	046	680.64938	
		800	3.4	18.93	27.23	997	777.67088	
		900	3.25	18.96	27.28	948	874.64338	

TABLE 12.—*Tabulation of* $10^5\triangle_n$ $10^5\triangle_{nb}$*, dynamic depth differences for stations 206-205, etc., in the Cape Chiniak Section.*

Depth in Meters	STATION 206-205	205-204	204-203	203-202	202-201
0	0 −8037	0 1051	0 −551	0 −125	0 175
25	−262 −7775	388 663	−276 −275	−37 −88	87 88
50	−637 −7400	726 325	−551 0	−125 0	175 0
100	−2287 −5750	1051 0			
200	−5937 −2100				
300	−7287 −750				
400	−7687 −350				
500	−8037 0				

TABLE 13.—*Tabulation of computed average velocities in miles per hour relative to the bottom between stations 206-205, etc., perpendicular to the Cape Chiniak Section.*

Depth in Meters	STATION				
	206-205	205-204	204-203	203-202	202-201
	K= .000099	.000099	.000099	.000099	.000099
0	-.796	.104	-.054	-.012	.017
25	-.770	.066	-.027	-.009	.009
50	-.733	.032	0	0	0
100	-.570	0			
200	-.208				
300	-.074				
400	-.035				

TABLE 14.—*Comparison of the average Cl o/oo, T^0, and $\sigma_{s,t,o}$ values for the three sections in 1928.*

Depth in Meters	Temperature			Cl o/oo			$\sigma_{s,t,o}$		
	Ocean Cape	Cape Cleare	Cape Chiniak	Ocean Cape	Cape Cleare	Cape Chiniak	Ocean Cape	Cape Cleare	Cape Chiniak
0	5.52	4.85	4.43	17.76	17.69	17.94	25.34	25.31	25.70
25	5.55	4.76	4.12	17.84	17.70	17.95	25.44	25.34	25.75
50	5.56	4.86	4.17	17.85	17.74	17.95	25.46	25.38	25.75
100	6.07	5.26	5.33	18.02	17.84	18.22	25.64	25.50	26.01

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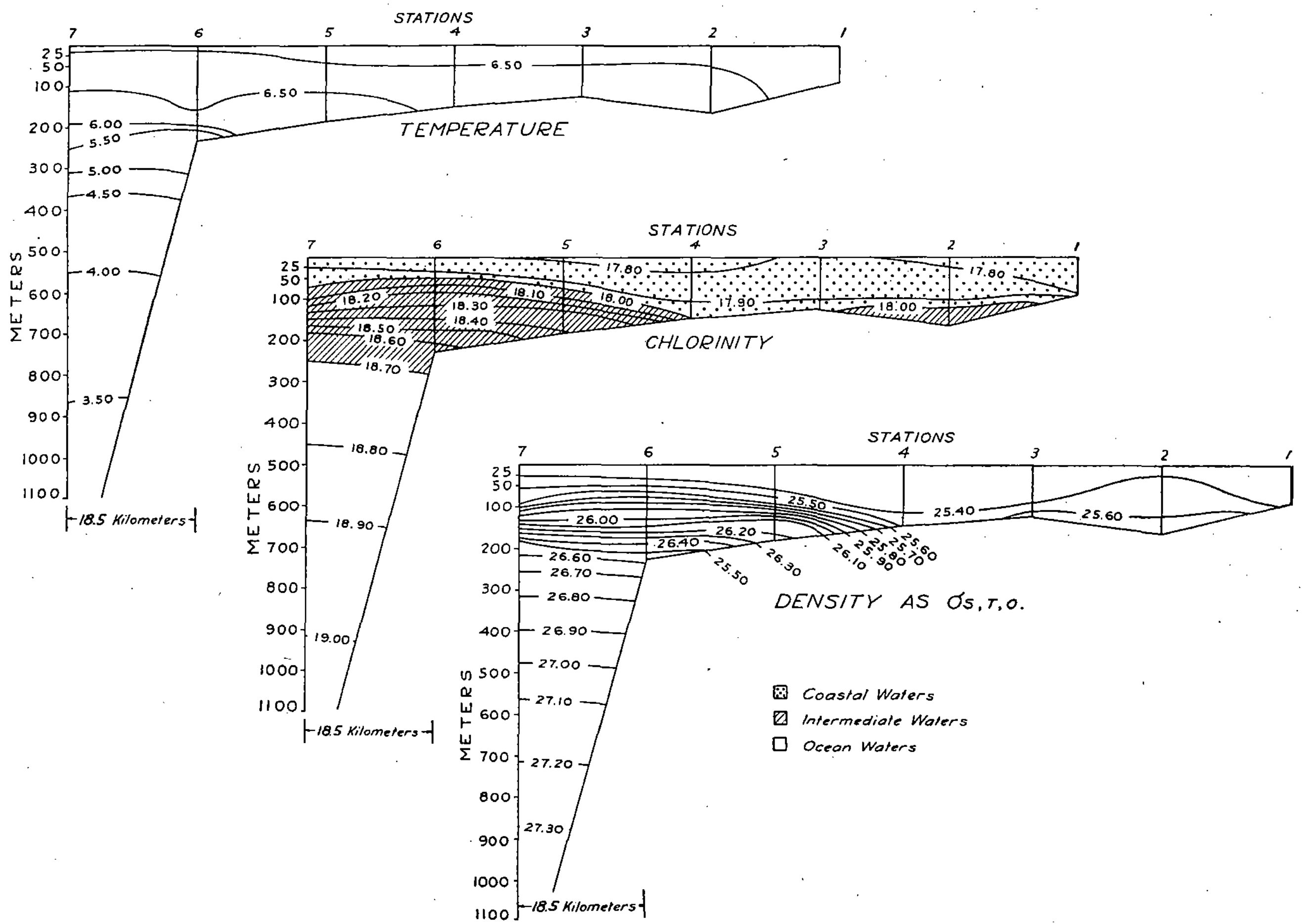

FIGURE 1.—Diagram of distribution of Temperature, *T*, Chlorinity, *Cl*, and $\sigma_{s,t,o}$ for Ocean Cape Section, 1927.

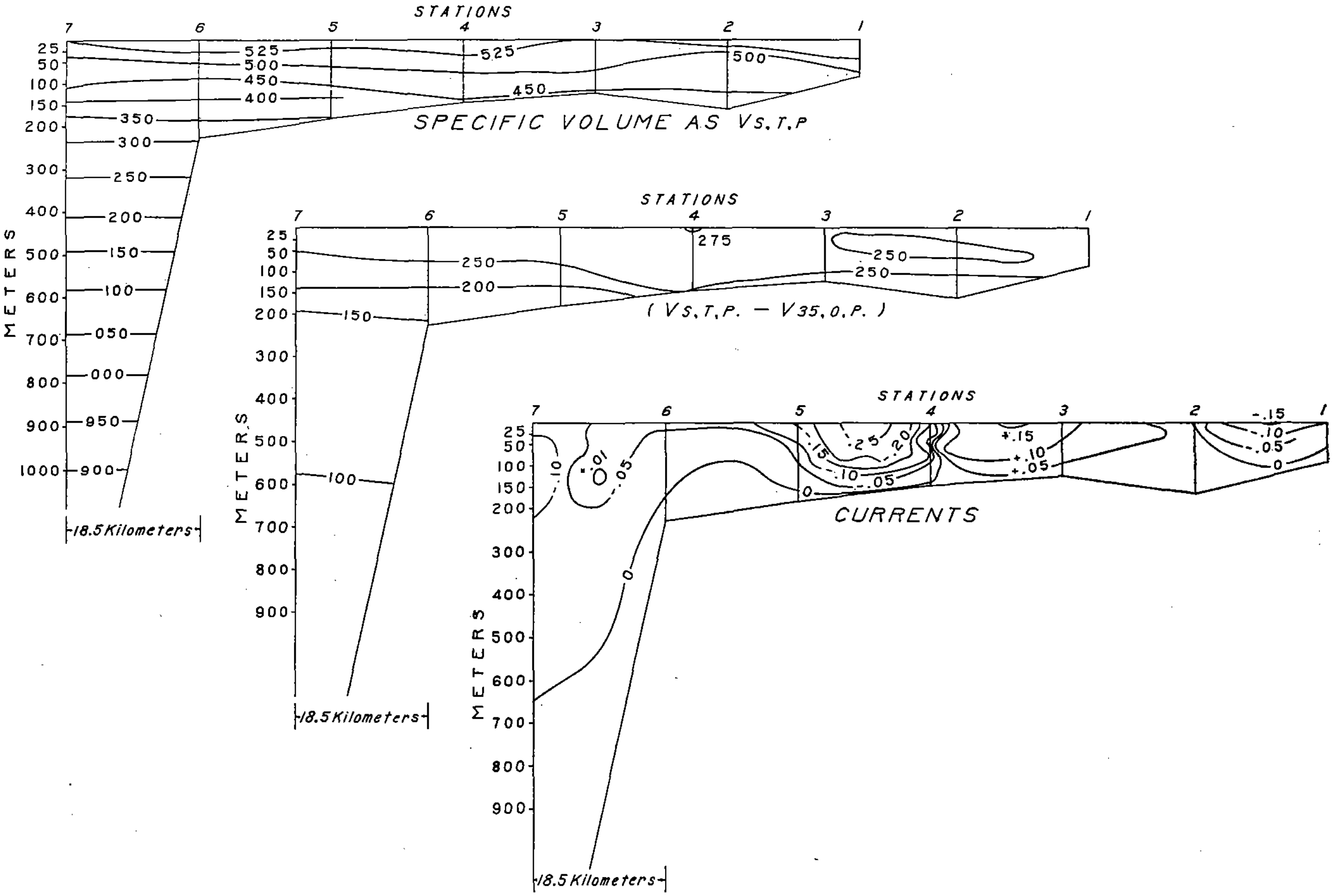

FIGURE 2.—Diagram of distribution of the specific volume *in situ*, $V_{s,t,p} - V$, and its anomaly $(V - V_{35,0,p})$ and the current, C, in miles per hour in the Ocean Cape Section, 1927.

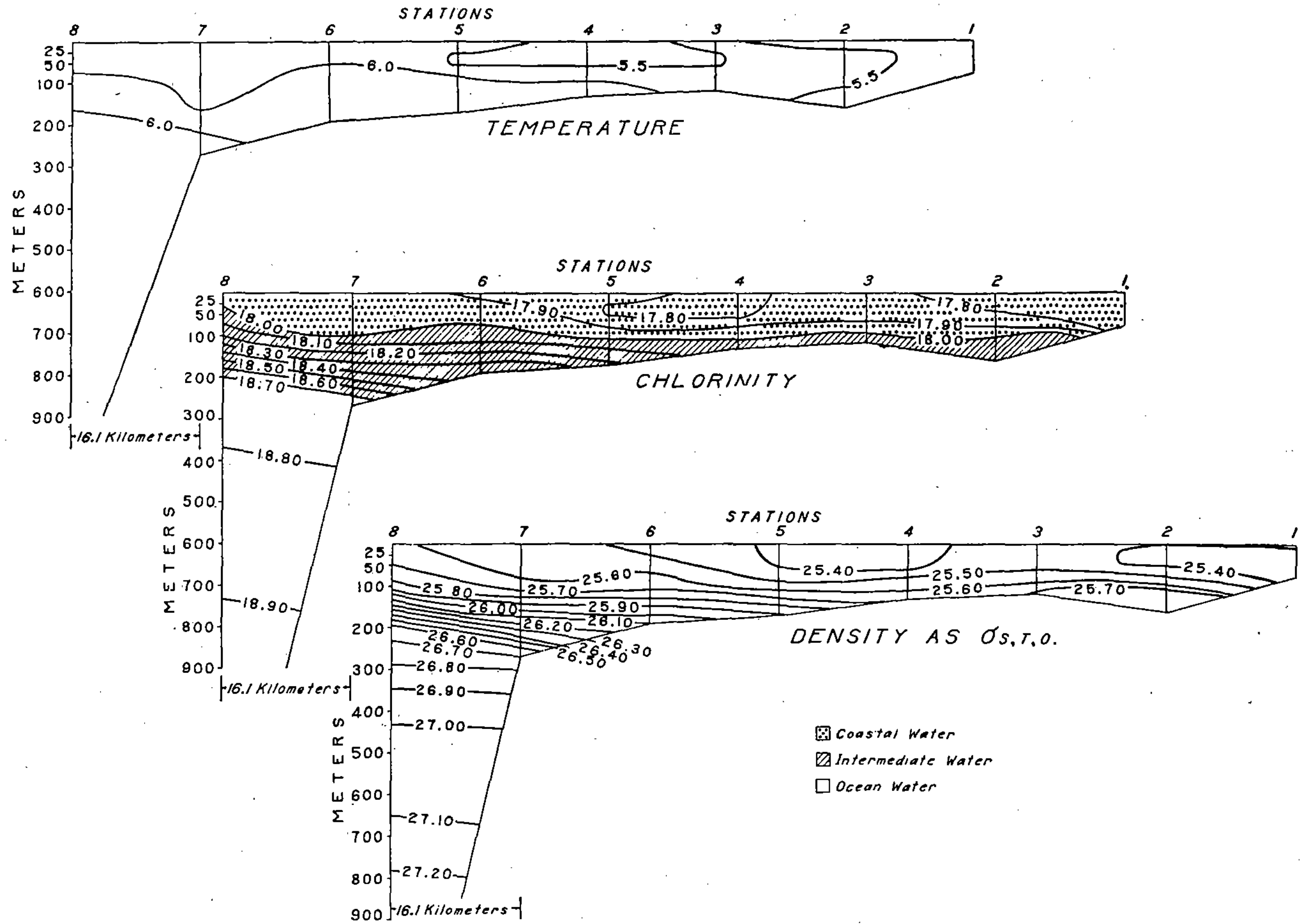

Figure 3.—Diagram of distribution of Temperature *T*, Chlorinity *Cl*, and $\sigma_{s,t,0}$ for Ocean Cape Section, 1928.

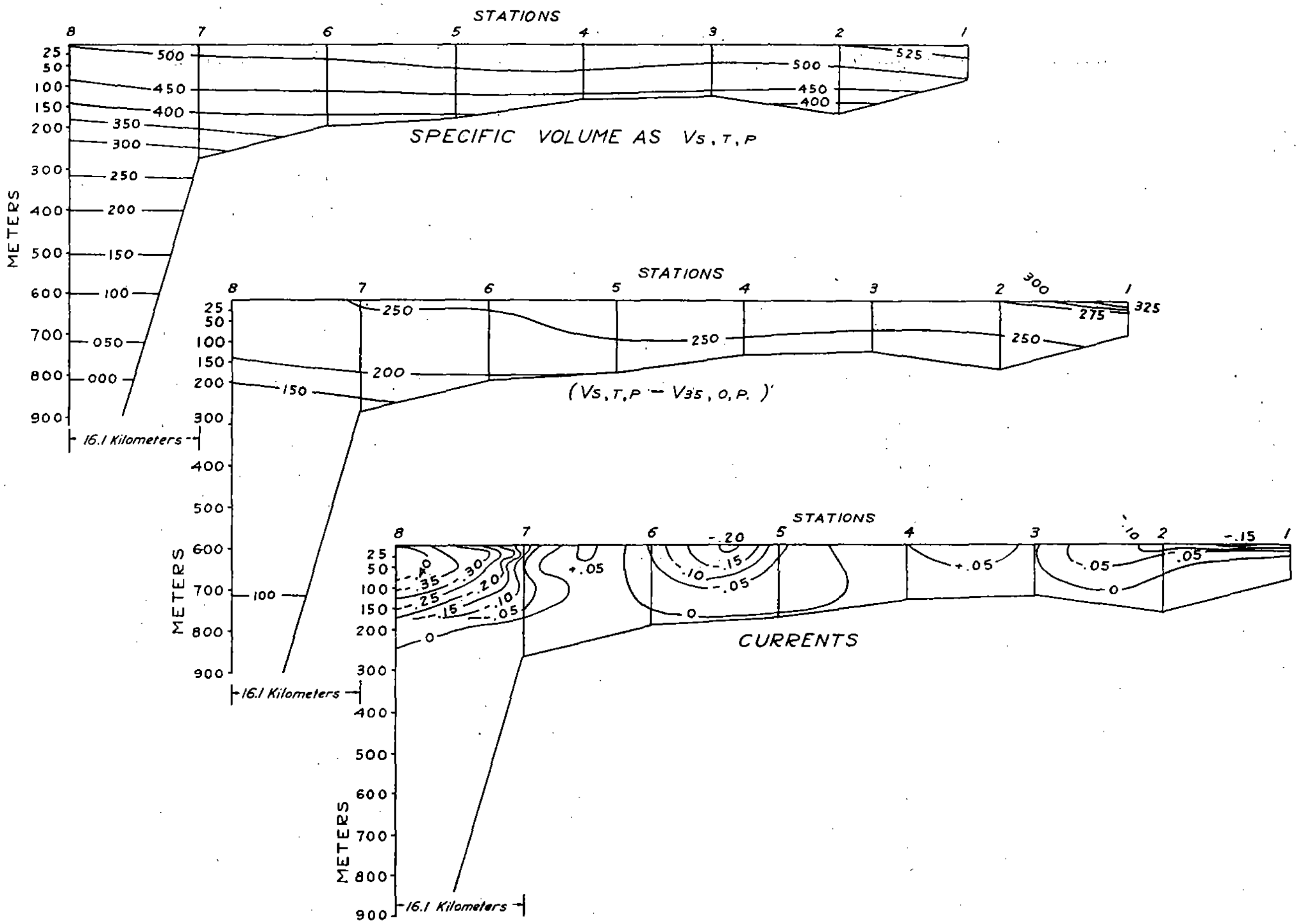

FIGURE 4.—Diagram of distribution of the specific volume *in situ*, $V_{s,t,p} = V$, and its anomaly $(V - V_{35,0,p})$ and the current, C, in miles per hour in the Ocean Cape Section, 1928.

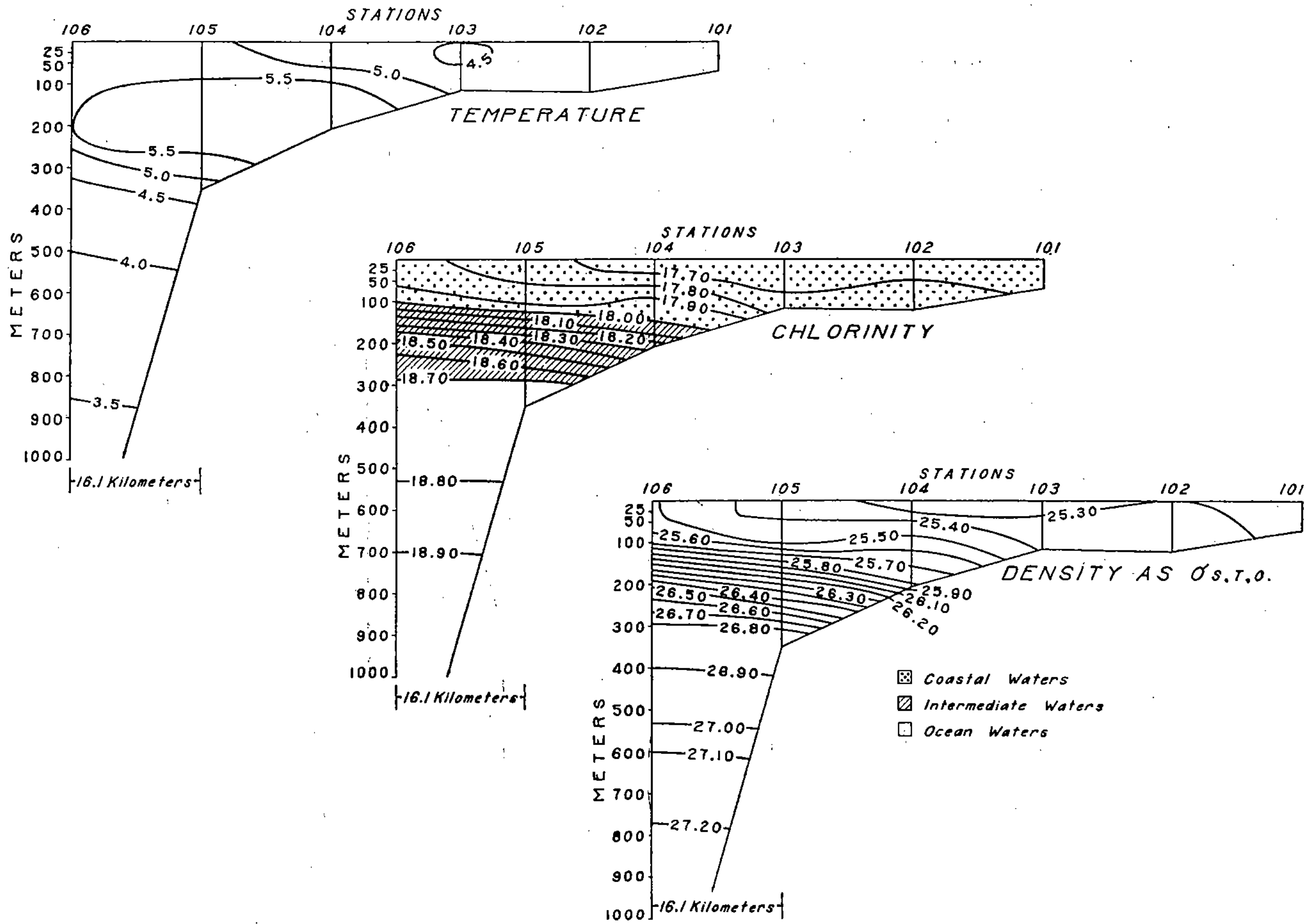

FIGURE 5.—Diagram of distribution of Temperature, T, Chlorinity, Cl, and $\sigma_{s,t,0}$ for Cape Cleare Section.

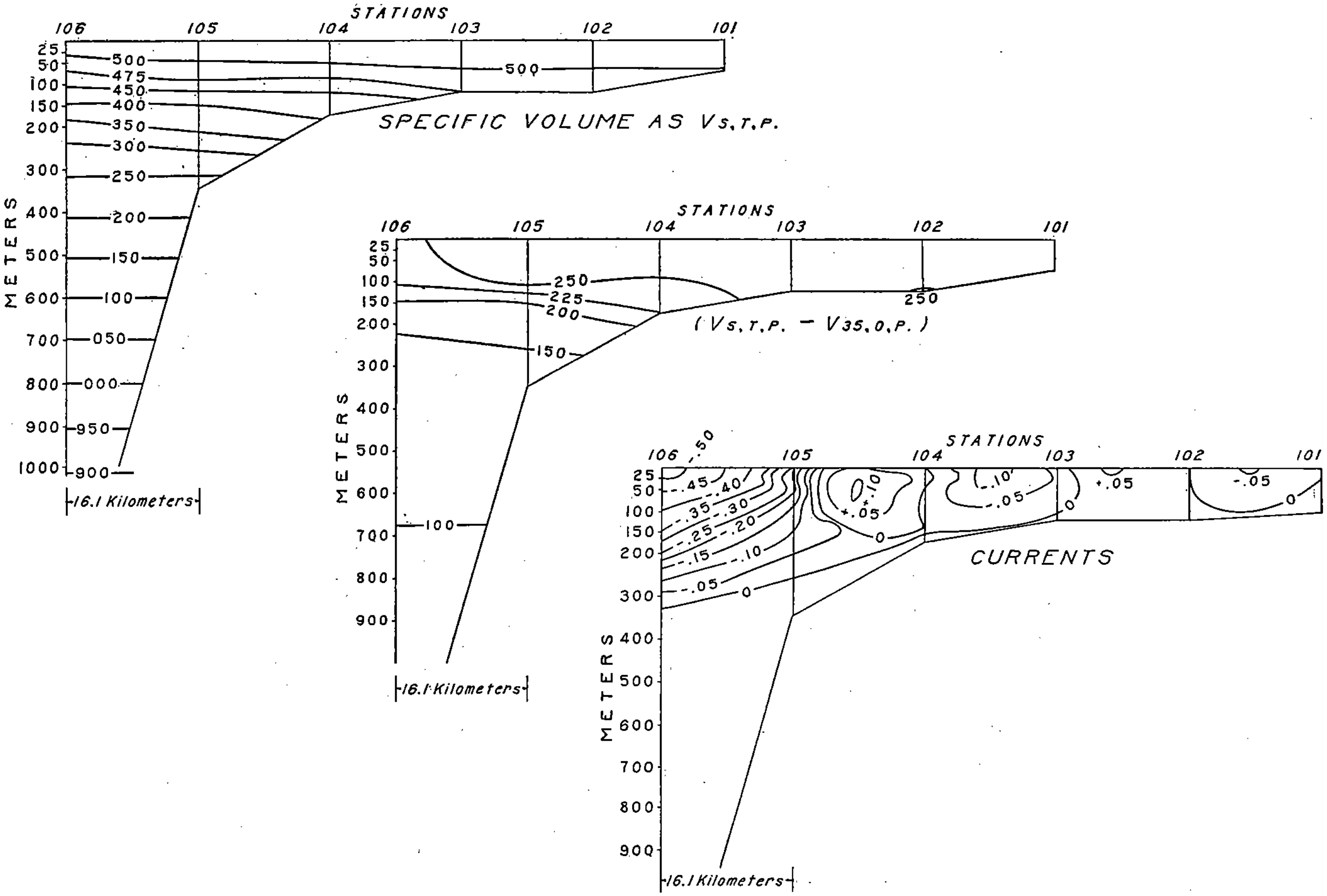

FIGURE 6.—Diagram of distribution of the specific volume *in situ*, $V_{s,t,p}$ —V, and its anomaly ($V—V_{35,0,p}$) and the current, C, in miles per hour in the Cape Cleare Section.

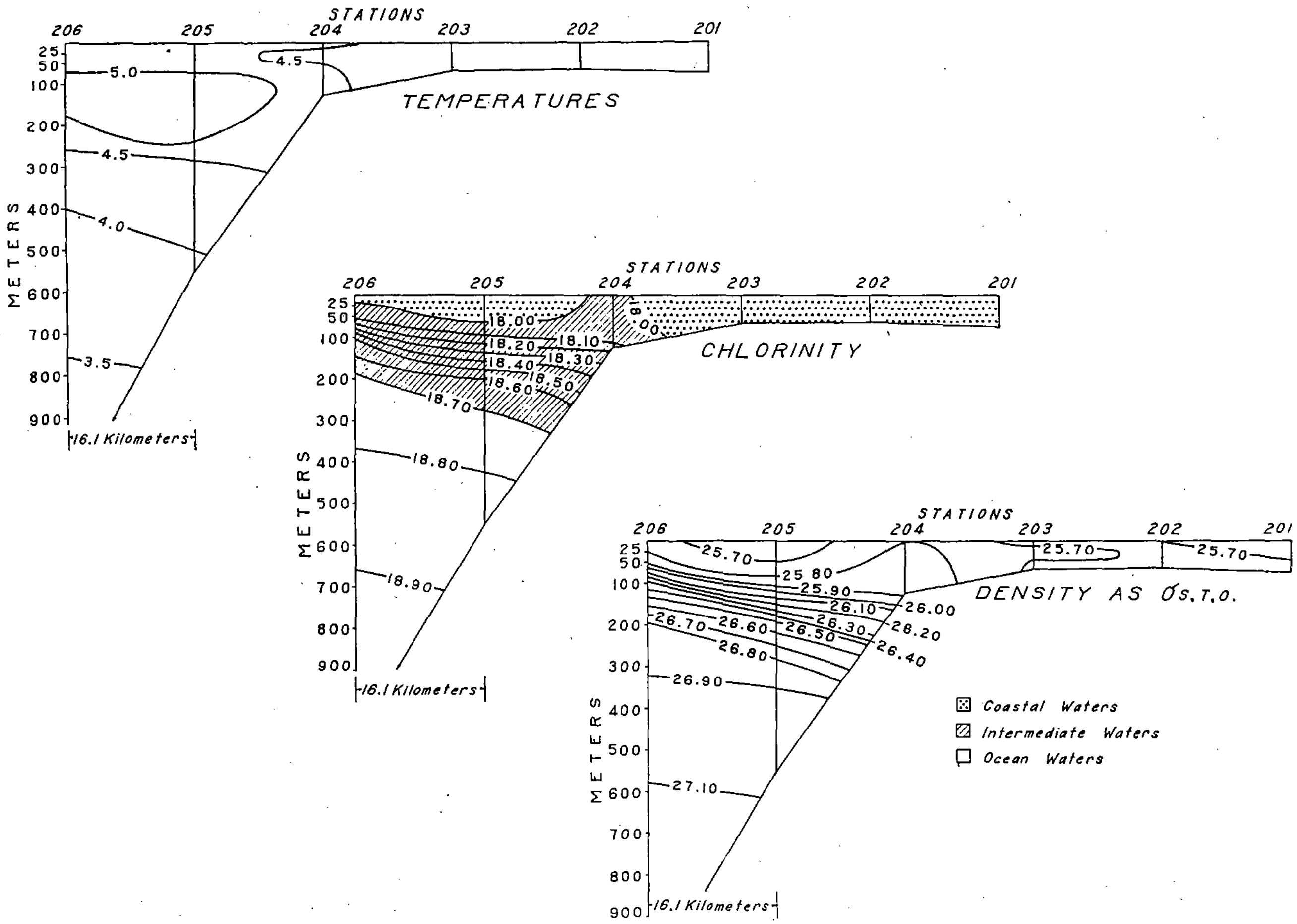

FIGURE 7.—Diagram of distribution of Temperature, T, Chlorinity, Cl, and $\sigma_{s,t,o}$ for Cape Chiniak Section.

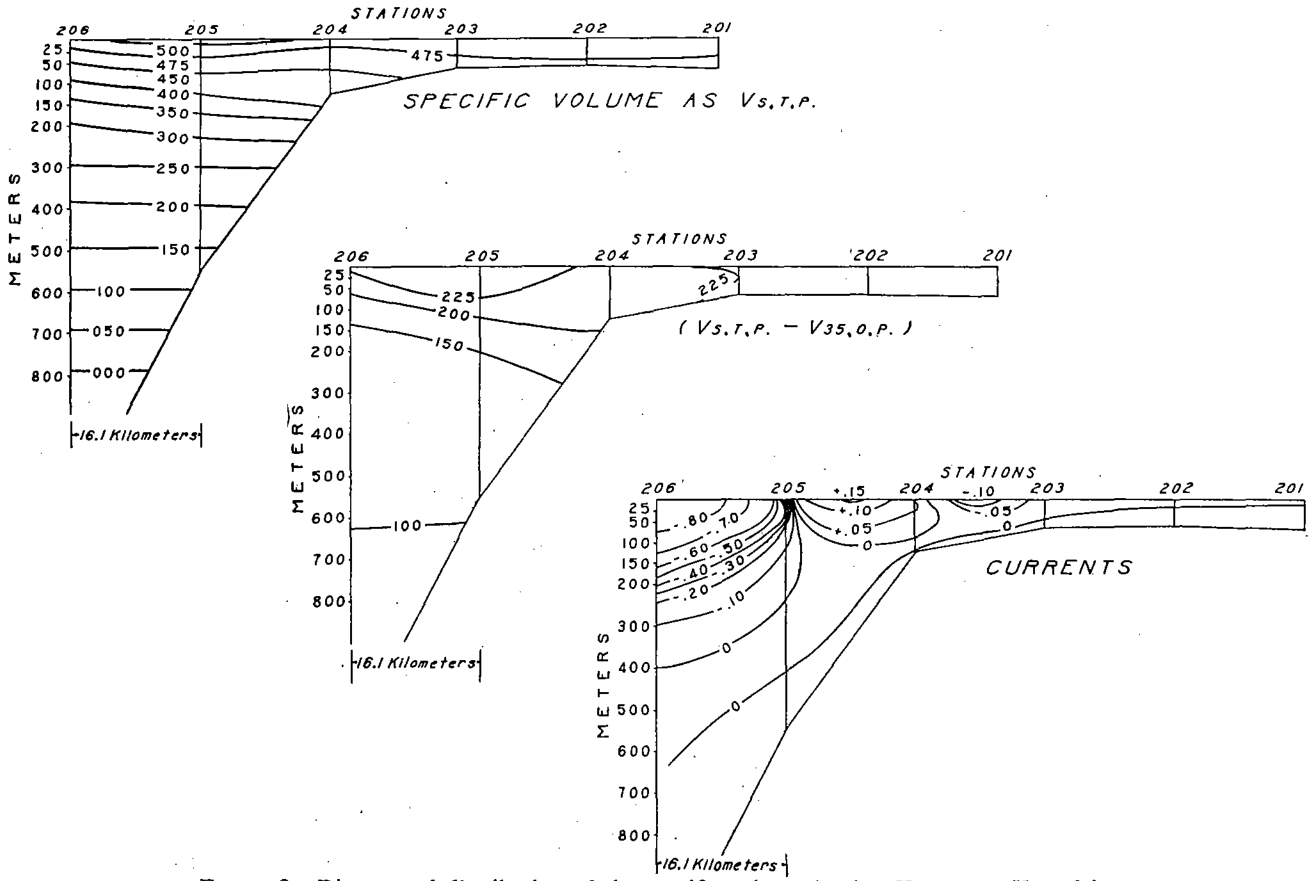

FIGURE 8.—Diagram of distribution of the specific volume *in situ*, $V_{s,t,p} = V$, and its anomaly $(V - V_{35,0,p})$ and the current, C, in miles per hour in the Cape Chiniak Section.

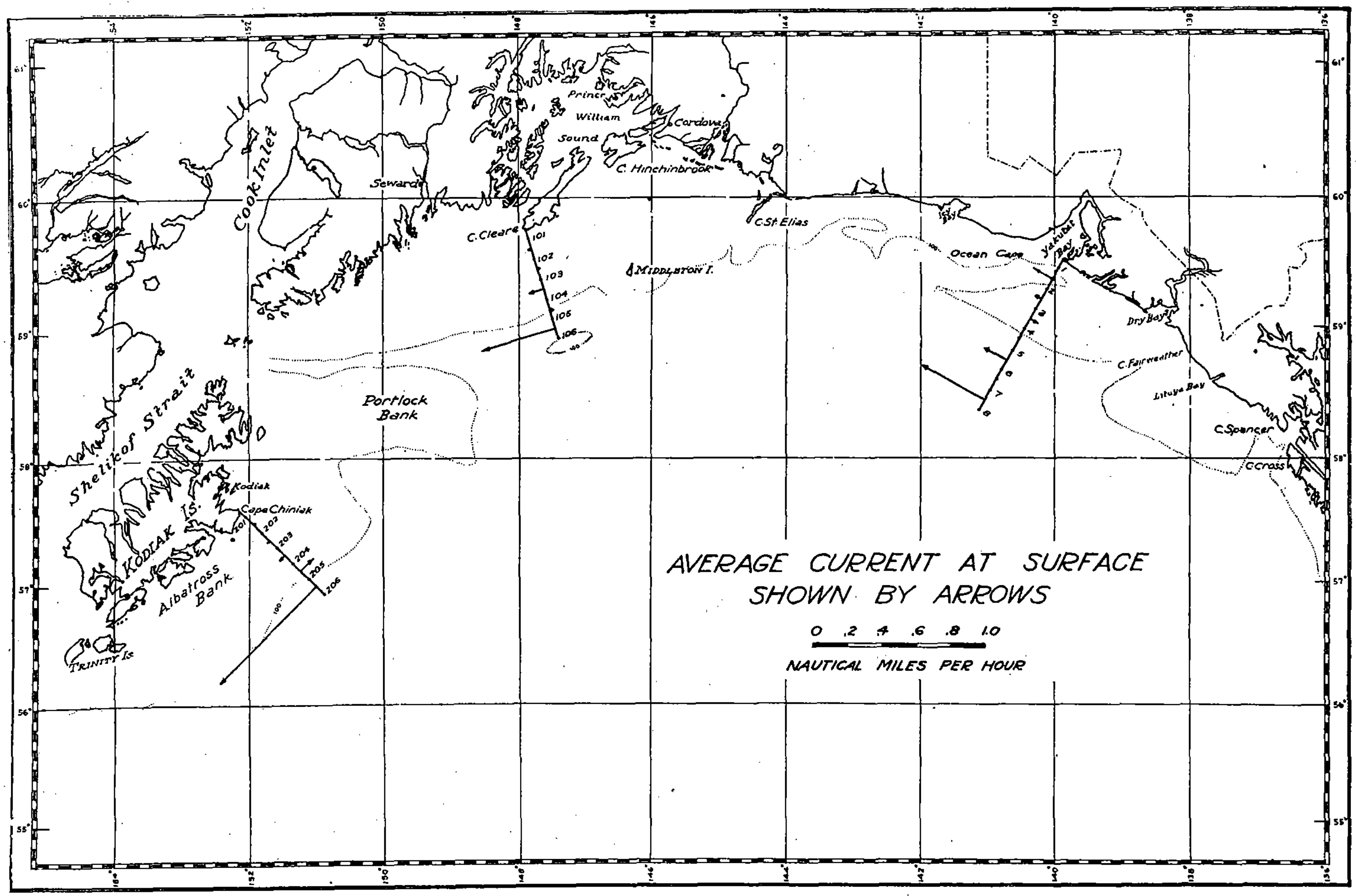

FIGURE 9.—The average current at the surface of Ocean Cape, Cape Cleare, and Cape Chiniak Sections in January, 1928.

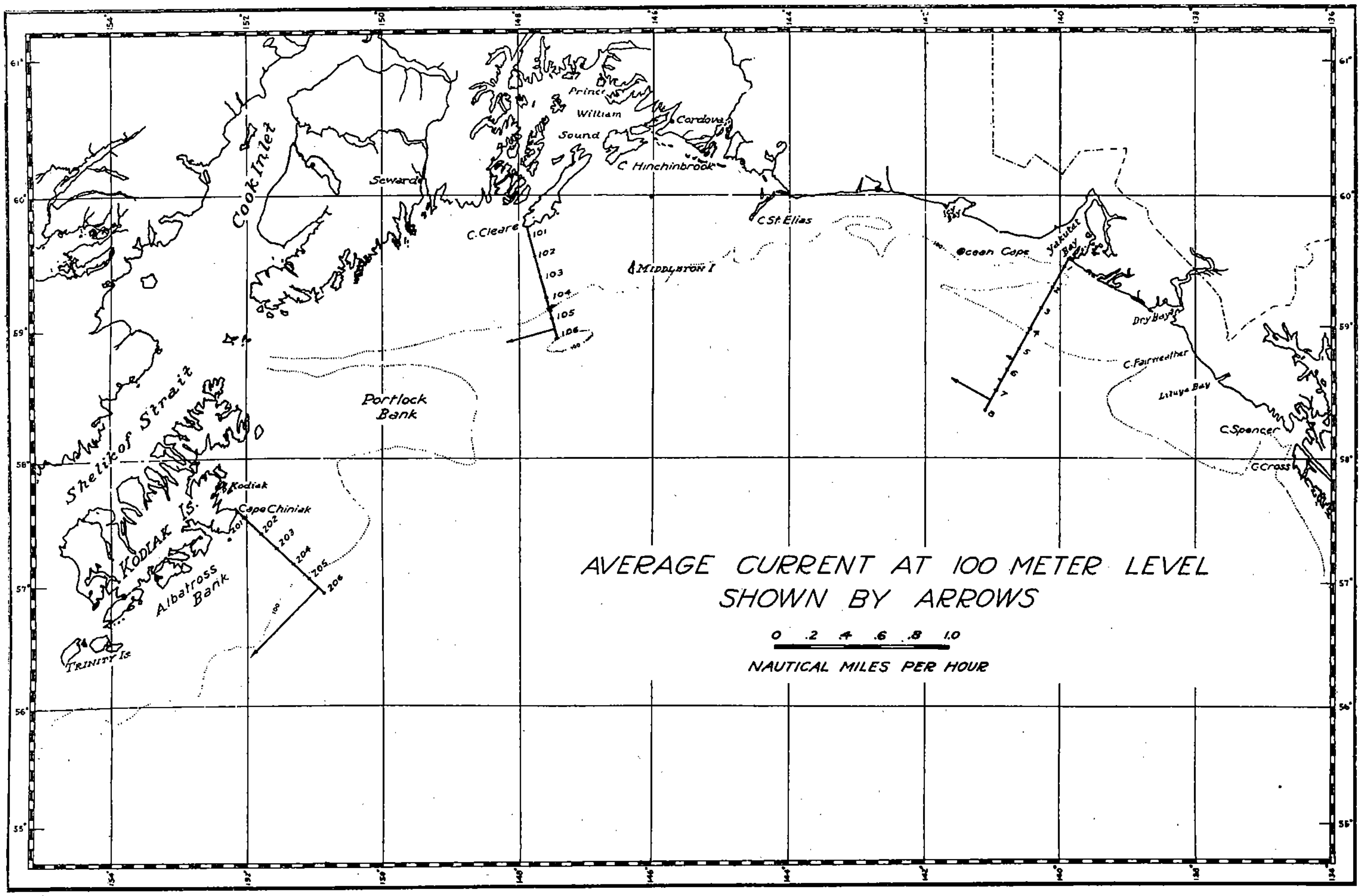

Figure 10.—The average current at the 100 meter level of Ocean Cape, Cape Cleare, and Cape Chiniak Sections in January, 1928.