

JOINT COMMITTEE ON OCEANOGRAPHY

TIDAL CURRENT OBSERVATIONS IN HECATE STRAIT

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May 15, 1953.

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## INTRODUCTION

Five short series of surface and bottom current measurements were made at one position in Hecate Strait during July 1952. These data showed that the surface currents were dextro-rotary, while the bottom currents were laevo-rotary and the dominant flows were parallel to the nearby coast-line. At the surface there was evidence of a steady southerly flow of about one-third knots.

The study was made in the vicinity of the main lemon sole migration route to provide information on the currents that might affect their movements.

## GEOGRAPHY

The location and principal geographic features of Hecate Strait are shown in Figure 1. Approaching the region from the south, the bottom gradually shoals from about 100 fathoms to from 10 to 50 fathoms off the north end of the Queen Charlotte Islands. From there the bottom falls away in Dixon Entrance to a depth generally exceeding 100 fathoms.

The principal feature of the bottom topography of northern Hecate Strait is the shallow water bank (less than 20 F.) extending 15 to 20 miles east from Graham Island and 60 miles south from Dixon Entrance. Between this bank and the eastern shore are two trenches from 50 to 60 fathoms deep, separated by a relatively

shallow ridge. The current measurements were made, as shown in the figure, at a position on the eastern edge of this ridge and may be considerably affected by the surrounding bottom topography

The tidal rise in northern Hecate Strait is marked by considerable diurnal inequality at low water and a range of more than twenty feet during spring tides. General observations recorded on the Canadian and Admiralty charts and in the Sailing Directions (British Columbia Pilot Vol II) indicate that throughout most of Hecate Strait the flood sets northward and the ebb southward in a simple reversing tidal system, while in northern Hecate Strait there is a region of confused and rotary tidal currents. The configuration of the tidal streams which might account for such a system have not been solved, but a consideration of the geography of the region indicates that the configuration may be complex.

In Hecate Strait the winds are generally from the north and less than twenty miles per hour in the summer. In the winter, they are from the south varying from light to gale force. The spring and autumn winds are variable in both strength and direction.

#### CURRENT MEASUREMENTS

The current measurements were made from H.M.C.S. Gedarwood during periods of light winds, when the ship could anchor without rolling excessively. During the survey there were only five such periods (Table 1) ranging in length from 5 to 40 hours, and of these, only two cover a complete tidal cycle and permit an analysis to determine the tidal and non-tidal flow.

Surface currents were measured every half hour with a current pole and log line (1). This apparatus consists of a sixteen foot pole weighted at one end to float upright in the water with about one foot showing above the surface. As it drifts away from the anchored ship it carries a light line marked at suitable intervals. The direction of the pole's drift is noted, and the time for a number of marks to "run out" is a measure of the current velocity.

The errors involved in current pole measurements are from "sail effect" due to the wind on the pole, stretching of the log line and irregularities in the paying out of the log line (especially during rough weather). These do not amount to more than 0.2 knots.

Bottom currents were also measured half-hourly at 40 fathoms depth using a standard Ekman propellor-type current meter (2). No correction of the observations for the effect of ship's roll has been attempted. However, the discussion of the results has been restricted to Series III and IV, made when the ship's roll was slight or non-existent. Under these conditions the observational errors are considered negligible.

#### DATA

##### SURFACE CURRENTS

The character of the surface currents is shown in Figures 2 and 4. The current direction rotates continually in a clockwise manner with an approximately semi-diurnal period. Accompanying this rotation is a pronounced cyclic variation in current speed, also with an approximately semi-diurnal period. Since these periods are alike and also similar to the period of tidal rise, a nearly constant phase relation exists between the current speed, current direction and tidal rise.

The salient features of this relation are evident from a comparison of the curves in Figure 2. At the time of low tide the current is a minimum and is directed nearly northward. As the tide rises the current increases in strength and changes direction in a clockwise manner until at high tide the current reaches its maximum speed and is directed nearly southward. As the tide falls, the current decreases in strength, and changes direction until at low tide it is again a minimum and directed northward.

Marmer (3) has shown that such surface currents can be analysed into rotary and steady currents of either tidal or non-tidal origin. The steady currents are determined by ~~summing~~ algebraically over a tidal cycle, the observed hourly values of the currents after they have been resolved into north-south and east-west components, and deriving the mean. Steady currents calculated in this way from Series III and IV are found to be 0.4 knots bearing  $210^{\circ}$  and 0.3 knots bearing  $190^{\circ}$  respectively.

Rotary tidal current speeds and directions have been calculated at the surface from Series III and IV by subtracting vectorially the steady currents from the observed currents. The results have been plotted as functions of time and are shown in Figure 3 for comparison with the observed currents. These tidal currents still exhibit a cyclic variation in speed but the range is less pronounced and during Series IV the period of variation was shorter and more irregular than that of the observed currents. The elimination of the steady current has also removed some of the irregularities in the rotation and made it more uniform throughout the tidal cycle.

The maximum calculated tidal currents during Series III

and IV are 1.25 knots and 0.9 knots respectively. Since Series III occurred at the time of spring tides, the 1.25 knots current probably represents one of the largest tidal velocities during the year at the point of observation. The decrease in velocity to 0.9 knots during Series IV can be associated with the neap tides.

#### Bottom Currents

The speeds and directions of the observed currents at a depth of 41-1/2 fathoms are shown in Figures 2 and 5. These currents, like the surface currents, rotate with a semi-diurnal period. The direction of rotation, however, is counterclockwise, and therefore opposite to the surface currents. The implications of this opposite rotation are that the direction of flow of the bottom currents with respect to the surface currents changes continuously during the period of rotation. Thus, at high and low water, when the bottom currents are directed north and south respectively, the surface currents are directed oppositely, while at approximately half-way between high and low water the bottom and surface currents flow in the same direction.

The variations in speed accompanying the rotation are not as pronounced as those of the surface currents with the result that the phase relation between the tidal rise and the current speed is not clearly defined. It appears from Figure 2 that the minimum speeds occur at approximately high and low water and the maximum speeds about half-way between high and low water -- indicating a period of about 6 hours or approximately half the period of rotation.

The occurrence of two maximum and minimum speeds during the period of rotation indicates the existence of rotary tidal currents

uncomplicated to any extent by accompanying steady currents (1,3). This observation has been verified by calculating the steady current speeds near the bottom from Series III and IV. In both cases the speed was less than 0.1 knots and therefore not large enough to obscure the form of the rotary currents.

#### DISCUSSION

An examination of the wind vectors shown on the surface current hodographs (figure 4) indicates that on no occasion during the periods of observation was the local wind directed so as to produce the observed steady southerly flow. In actuality, the currents produced by the local winds would have northerly components and a tendency, therefore, to reduce the steady flow. On the days preceding the periods of observation the winds blew from the west and northwest. In view of the nearby land configurations, such winds could produce surface currents in a southerly or southeasterly direction. According to Ekman (4) the time taken during the transient state for a wind driven current to reach approximately its equilibrium value is of the order of two to three hours. Reversing this argument indicates that local currents, produced by local winds on the days preceding the observations, would not endure for more than a few hours after the winds died away. It is therefore concluded that, although the local winds modify the steady flow, they do not by themselves account for it.

The only run-off into Hecate Strait which might account for the observed steady flow comes from the Skeena River. The surrounding land configuration and Coriolis force combine, however, to direct the river out-flow northward rather than southward, and in such a way that it does not flow at all in the region of the

current measurements.

#### CONCLUSIONS

At this position the tidal currents are rotary, with the dominant directions and velocity parallel to the coast-line. The surface currents rotate clockwise semi-diurnally with a maximum of 1.0 to 1.5 knots southward, and the minimum less than 0.1 knots northward. The net progress of the water is southward at about 0.4 knots.

The bottom currents at 41 fathoms depth vary irregularly from 0.2 to about 0.6 knots, and rotate counterclockwise, opposite to the surface currents.

These observations do not contribute materially to knowledge of the circulation, or tidal system in Hecate Strait. They only define the character of the currents at the position and time of observation. There is no evidence that the component of steady southward flow is associated with wind or land drainage wherefore it must be associated with the tidal circulation in some manner, and may be a transitory feature.

## REFERENCES

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2. Ekman, V.W. An Improved Type of Current Meter. J. de Conseil, 7 (1), pp. 3-10, 1932.
3. Marmer, H.A. Coastal Currents Along the Pacific Coast of the United States, U.S. Department of Commerce, Coast and Geodetic Survey, Special Publication No. 121, 1926.
4. Ekman, V.W. A Survey of Some Theoretical Investigations Ocean Currents. J. de Conseil III (3), pp. 295-327, 1928.
5. Cameron, W.M. Fresh Water in Chatham Sound. Progress Report of the Pacific Coast Stations, F.R.B. of Canada, #76, pp. 72-75, October 1948.

TABLE I

## SUMMARY OF OBSERVATIONS

| Series | Date<br>1952 | Duration<br>(hours) | No. of Surface<br>Current Observations | No. of Bottom<br>Current Observations |
|--------|--------------|---------------------|--|---------------------------------------|
| I      | July 12-13   | 22                  | Nil                                    | 43                                    |
| II     | July 18      | 5                   | 9                                      | Nil                                   |
| III    | July 20-21   | 27                  | 51                                     | 53                                    |
| IV     | July 24-26   | 41                  | 80                                     | 86                                    |
| V      | July 26-27   | 9                   | 18                                     | 38                                    |

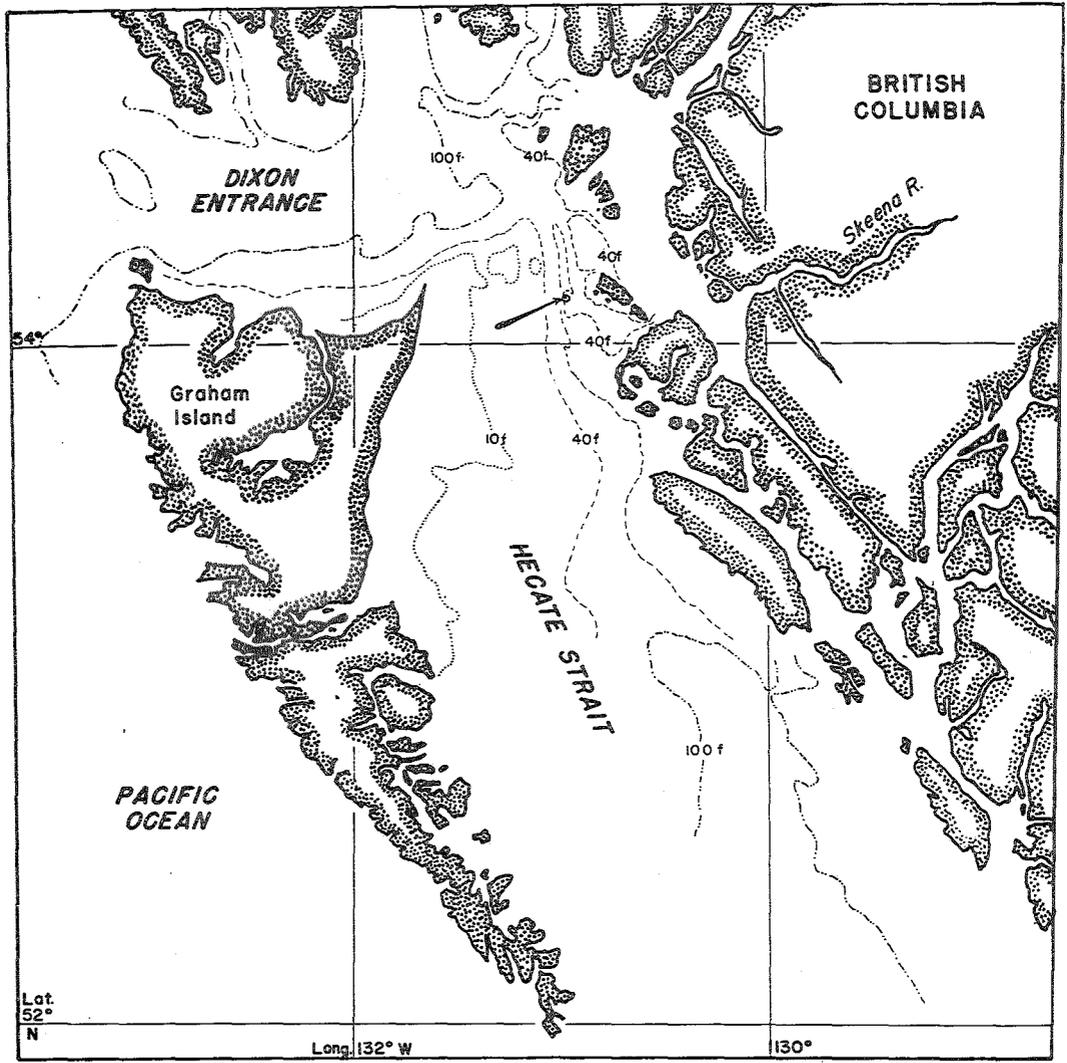


Figure 1

Chart of Hecate Strait and surrounding region  
showing the location of the anchor station.

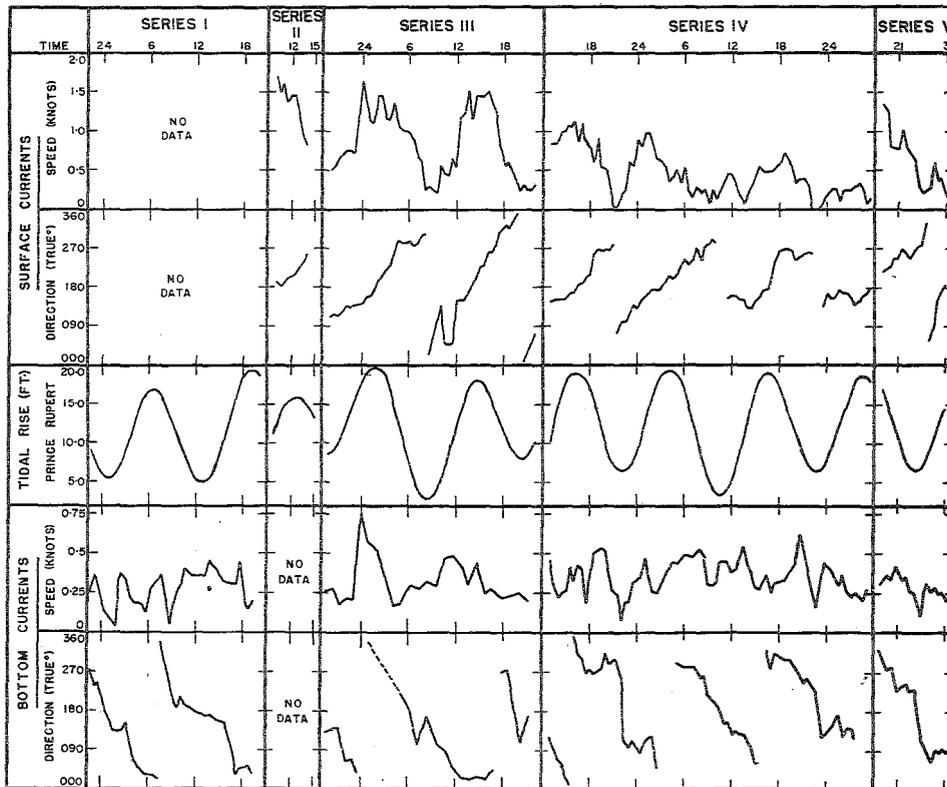


Figure 2

Surface current speeds and directions, bottom current speeds and directions, and the tidal rise at Prince Rupert, during five series observed in July 1952. (Times are P.D.S.T.).

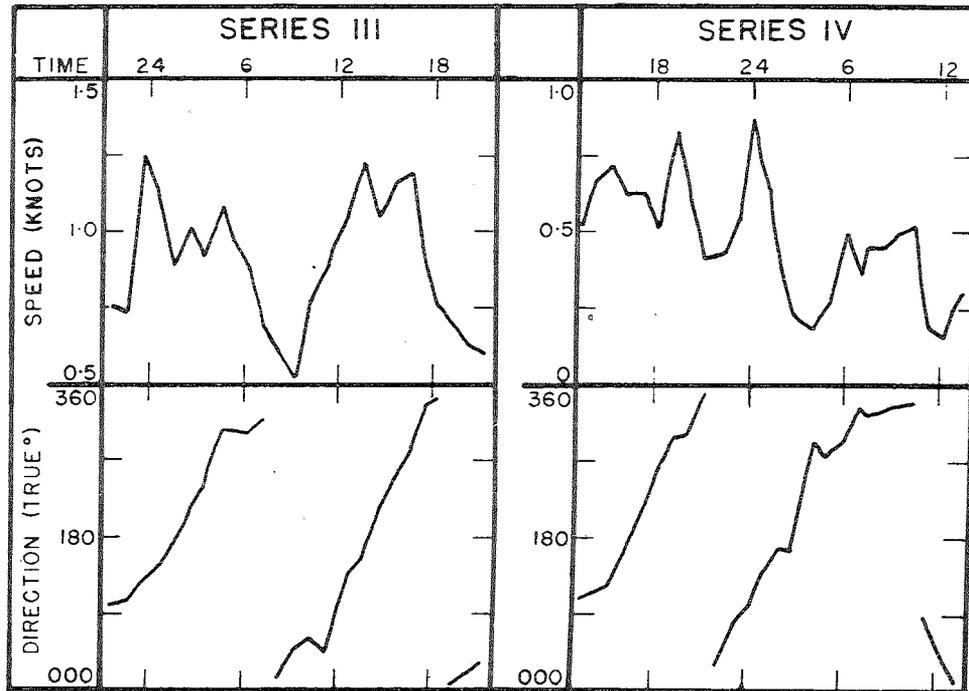


Figure 3

Series III and IV surface current speeds and directions with the steady flow eliminated.

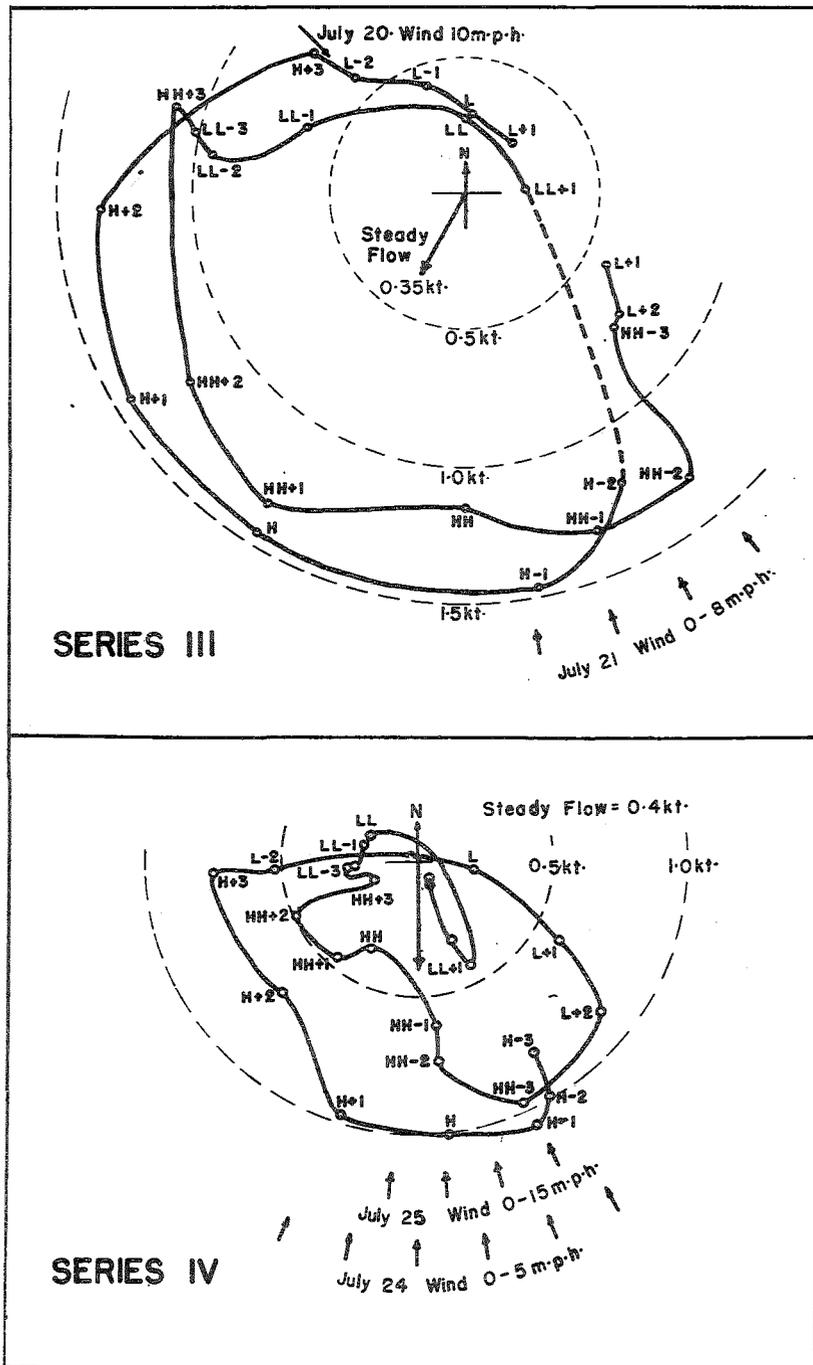


Figure 4

Series III and IV surface current hodographs. Wind vectors during the period of observation and on the day preceding the observations are also shown.

