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A Survey of Water Conditions in the
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Introduction

This report is one of a series on the waters of Grand Manan Channel. When the series is completed, a comprehensive review of previous work is contemplated. In an earlier report (McLellan, 1951), the results of a survey of water conditions in the Grand Manan Channel in September, 1950, were discussed. At that time the effect of summer warming had just passed its peak and a minimum variation in salinities was to be expected. A similar survey carried out in April, 1952, had as its object the observation of conditions in the channel at the time when the effects of the spring run-off were most pronounced.

As in the September survey, stations were occupied along five lines, three in the channel proper and two in the northern, and northeastern, approaches. All lines except that across the northern approaches were essentially similar to those occupied previously. This line was occupied as part of another survey which was completed just before the Grand Manan Channel survey began. It ran from a point north of Head Harbour to the Wolves. Figure 1 shows a chart of the area with bottom contours and the lines of observations. Both the September, 1950, and the April, 1952, lines across the northern approaches are shown.

The survey made use of a sea-sampler, which minimized delay at stations, permitting a fair approximation to simultaneity in each section. Sections were so timed that either high or low water occurred while they were being run. Four of the lines were run at low water and again at high water while the line across the northern approaches was

occupied at about two hours after high and low waters. Details of the sections are given in Table I. The survey was carried out at the time of new moon with the moon near perigee so that tidal ranges were near a maximum. Winds were light and variable and had been so for a few days previous to the time of the survey.

TABLE I

Data on Survey Sections

1. Northern End: From West Quoddy Head to beyond Long Eddy Point:
Lat. 44 49.0'N. Long. 66 56.0'W. to Lat. 44 49.0'N. Long. 66 44.1'W.
Length of section 8.5 miles (15.7 Km.). Number of observations per section, 6. Average time per section 1 hr. 25 min.
2. Southern End: From Little River to Southwest Head:
Lat. 44 39.0'N. Long. 67 10.9'W. to Lat. 44 36.0'N. Long. 66 55.0'W.
Length of section 11.9 miles (22.0 Km.). Number of observations per section, 7. Average time per section 1 hr. 35 min.
3. Longitudinal: From West Quoddy Head to Southwest Head:
Lat. 44 49.0'N. Long. 66 56.0'W. to Lat. 44 35.0'N. Long. 66 57.9'W.
Length of section 14.1 miles (26.1 Km.). Number of observations per section, 8. Average time per section 1 hr. 45 min.
4. Northeastern Approaches: From Long Eddy Point to the Wolves:
Lat. 44 49.0'N. Long. 66 46.1'W. to Lat. 44 58.0'N. Long. 66 40.0'W.
Length of section 10.0 miles (18.5 Km.). Number of observations per section, 6. Average time per section 1 hr. 20 min.
5. Northern Approaches: From Head Harbour to the Wolves:
Lat. 44 57.9'N. Long. 66 52.5'W. to Lat. 44 58.4'N. Long. 66 43.7'W.
Length of section 6.3 miles (11.7 Km.). Number of observations per section, 5. Average time per section 1 hr. 20 min.

Observations

The temperatures and salinities observed are shown in vertical sections in figures 2 to 6 inclusive. In all cases temperature observations were made down to within a few metres of the bottom. Salinity observations were obtained to a considerably lesser depth as was unavoidable because of the method by which sample bottles are tripped in the sea-sampler. All observations were made from a stopped ship and subsurface observations were supplemented by surface samples and surface temperature determinations.

Salinities ranged from 30.6 ‰ to 32.0 ‰ and temperatures from 3.5 C. to 4.5 C.

1. Northern End: The section from West Quoddy Head to a point beyond Long Eddy Point is shown in figure 2. At low water, temperatures were generally lower than 3.75 C. with a tongue of water colder than 3.5 C. extending from West Quoddy Head to the centre of the section. The deepest water and a surface patch north of Long Eddy Point were slightly above 4.0 C. The salinity range was from less than 30.8 ‰ to greater than 31.7 ‰ in the centre of the section. In general, higher salinities and greater stratification occurred to the eastward. At high water, temperatures were almost uniform and approximately 3.75 C. Except for a patch of low salinity water (less than 31.2 ‰) at the surface just north of Long Eddy Point, salinity increased regularly from west to east (31.4 ‰ to 31.6 ‰).
2. Southern End: Figure 3 shows profiles across the southern end from Little River to Southwest Head. At low water, temperatures varied from less than 3.75 C. at the surface to greater than 4.0 C. at the bottom. The salinity was approximately 31.5 ‰ in the western half except for a small patch in the extreme west greater than

31.6^o /oo. To the east, there was some vertical stratification with salinities, varying from 31.6^o /oo to 31.8^o /oo. At high water, both temperature and salinity increased from west to east, temperatures ranging from 3.75^o C. to 4.25^o C., and salinities from 31.6^o /oo to 31.8^o /oo. In the centre of the section, the column was almost homogeneous, with salinity 31.70^o /oo and temperature 3.9^o C.

3. Longitudinal Section: The diagonal sections from West Quoddy Head to Southwest Head are shown in figure 4. At low water, the temperature throughout the section was approximately 3.75^o C. and salinities increased from 31.4^o /oo at the surface in the northern end to 31.7^o /oo at the bottom in the southern end. The greater stratification was observed in the northern end with a top to bottom variation from 31.4^o /oo to 31.6^o /oo. At high water, the intrusion of waters from the south was evident in a 4.0^o C. isotherm which extended more than half way up the section. This was true also of the 31.70^o /oo isohaline. Salinities greater than 31.9^o /oo were observed at the extreme southern stations.
4. Northeastern Approaches: The line across the northeastern approaches (figure 5) ran from Long Eddy Point to a point north and east from the Wolves. At low water the upper 50 metres displayed temperatures of approximately 3.75^o C. in the whole section except for a body of water less than 3.5^o C. east of the Wolves. In the deep water between the Wolves and Long Eddy Point temperatures increased with depth to greater than 4.5^o C. Except for the station closest to Grand Manan, where stratification was low, there was a marked layer of changing salinities (31.4^o /oo to 31.8^o /oo) which sloped downward from 40 metres in the south to about 70 metres in the north. Bottom

salinities in the deep water at the south end of the section were as high as $32.0^{\circ}/\text{oo}$. At high water, the temperature distribution was little changed from that at low water with the exception that there was a considerable decrease in the amount of water colder than 3.5°C . The high salinity bottom water had left the section and there was no water with salinity greater than $31.7^{\circ}/\text{oo}$.

5. Northern Approaches: In the section across the northern approaches (figure 6), some two hours after low water, temperatures ranged from 4.0°C . at the surface, and down to 40 metres at the western end, to less than 3.5°C . in a tongue along the bottom at the eastern end. Salinities in the top 20 metres were less than $31.0^{\circ}/\text{oo}$ and as low as $30.6^{\circ}/\text{oo}$ with higher salinities (greater than $31.7^{\circ}/\text{oo}$), concentrated about the bottom near the centre of the section. Two hours after high water both the 4.0°C . isotherm and the 3.5°C . isotherm had retreated so that temperatures were mainly in the vicinity of 3.75°C . There was little water in the section with salinity less than $31.0^{\circ}/\text{oo}$, and almost all the water deeper than 70 metres had salinities greater than $31.8^{\circ}/\text{oo}$.
6. Time Series: A short time series was observed at Latitude $44^{\circ}46.05'\text{N}$. Longitude $66^{\circ}51.6'\text{W}$. from 1800 to 2200 hrs. on the 24th of April. The series of five observations about low water, are plotted in figure 7. Temperatures varied from slightly less than, to slightly greater than 4.0°C . with the higher temperatures occurring in the top 30 metres at the time of low water. A salinity minimum (less than $31.3^{\circ}/\text{oo}$) associated with the temperature maximum developed with the occurrence of low water and had begun to retreat by 2200 hours.

DISCUSSION

This survey found temperatures ranging from 3.5^o C. to 4.5^o C. and salinities from 30.6^o /^oo to 32.0^o /^oo as compared to the September, 1950, survey when temperatures ranged from 10.0^o C. to 12.1^o C. and salinities from 32.4^o /^oo to 33.0^o /^oo. Where winter chilling had increased the uniformity of temperatures, the admixture of fresh water from the spring run-off had produced a greater range of salinities.

A comparison of the high water section across the southern end (figure 3) and the low water section across the northern end (figure 2) would indicate that the waters to the south had higher average salinity and weaker stratification than those in the north end of the channel. This may not be true for waters south of Machias Seal Island, but may only reflect the mixing that takes place over the southern shoals. The movement of waters up and down the channel with the tide is well illustrated by the configuration of isotherms and isohalines in the longitudinal section (figure 4). A movement of at least 7.5 miles (13 Km.) is indicated, which is consistent with tidal currents of 2 knots (103 cm/sec) maximum velocity (Dawson, 1908). In the northern section (figure 2), the concentration of low salinities towards the eastern end would suggest that much of the fresher waters which were found in the northern and northeastern approaches, flow south on the eastern side of Grand Manan, although the time series (figure 7) indicates some intrusion into the channel along the Grand Manan shore at low water.

The variation in mean salinity from a higher value in the southern section to a lower value at the northern end shows that both waters contribute to the mixture which comprises the waters of the channel proper. The distribution of temperature and salinity in these sections does not

demonstrate any obvious flow superimposed upon the tidal oscillations. It is difficult to visualize a northward flow (Mavor, 1922) carrying the well mixed water of the channel through the northern or northeastern approaches, as both of these sections (figures 5 and 6) displayed relatively marked stratification at high water and at low water. It seems possible, from the observation, that some channel water might escape around Long Eddy Point at high water, but it seems more likely that any dominant flow is towards the southern end where stratification is always quite low (MacGregor and McLellan, 1952). Arguing from the point of view of dynamic tendencies, it might be expected that low salinity surface waters from the northern approaches would flow southward into the channel and that higher salinity waters from the south should move up along the bottom. The trend of isotherms and isochalines in the longitudinal section (figure 4) could be construed as indicative of such a two-way flow.

SUMMARY

1. Sea-sampler observations were made at high water and at low water along three lines in the Grand Manan Channel and two in the northern and northeastern approaches. Except for the northern approaches, the lines were similar to those observed in September, 1950.
2. Temperatures ranged from 3.5^o C. to 4.5^o C. and salinities from 30.6^o /oo to 32.0^o /oo. This compared to 10.0^o C. to 12.1^o C. and 32.4^o /oo to 33.0^o /oo in September, 1950. These ranges refer to the whole area of survey. The variations within the channel proper were much less.
3. Vertical gradients in both temperature and salinity were small in

- the channel and especially so in the central and southern parts.
4. Waters from both the northern and southern ends were involved in the well mixed channel waters.
 5. It is suggested that there may have been augmentation from the north at the surface and from the south along the bottom while non tidal flow, if present, was probably directed towards the south.

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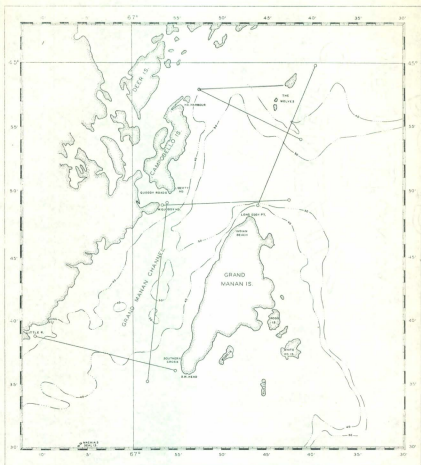


Figure 1.

The Grand Manan Channel area showing bottom contours and lines of observations.

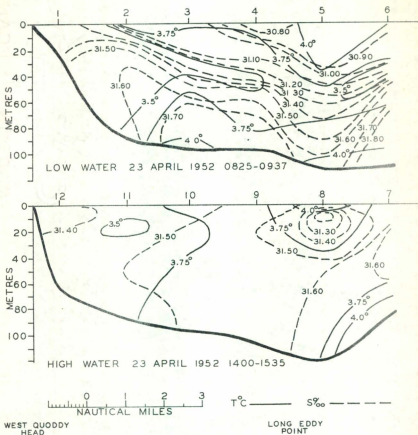
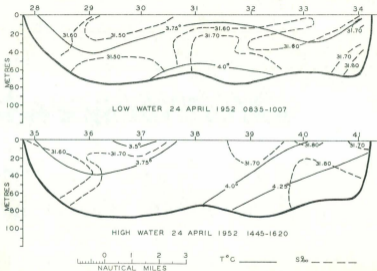


Figure 2

Northern End: Temperature and salinity in profile.



LITTLE RIVER

Figure 3

S.W. HEAD

Southern End: Temperature and salinity in profile.

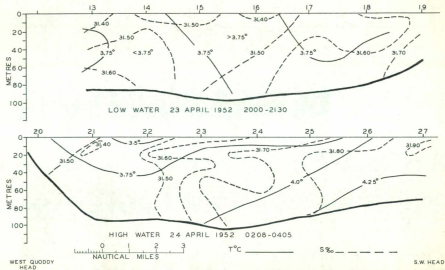


Figure 4

Longitudinal Sections: Temperature and salinity in profile.

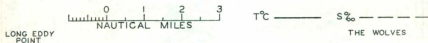
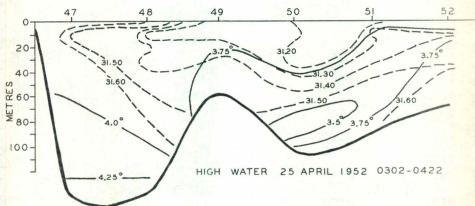
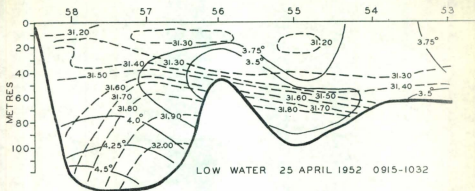


Figure 5

Northeastern Approaches: Temperature and salinity in profile.

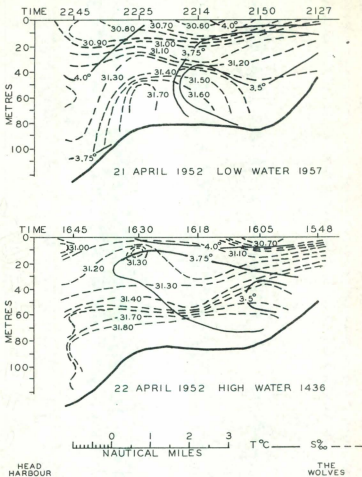


Figure 6

Northern Approaches: Temperature and salinity in profile.

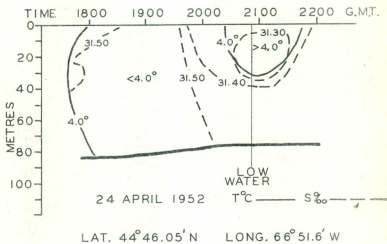


Figure 7

Temperature and salinity variations in a short time series in the Grand Manan Channel.



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