Salinity Features of the St. Jean Estuary, Gaspé, Quebec, Canada

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Introduction

The salinity of the St. Jean Estuary was measured and analyzed to be able to categorize it under the estuary classifications of well-mixed estuary, partially-mixed estuary, salt-wedge estuary, or fjord-type estuary (Boggs, 1987). An estuary is an environment of changing salinities due to seawater at one opening and fresh water at the other. Estuaries are classified according to the degree of mixing between these two forces. It is important to note which factor is dominant in a certain estuary. An estuary dominated by tides will have seawater traveling far up into the main body of the estuary. On the other hand, if an estuary is mainly influenced by river influx, fresh water travels farther into the main body of water creating a less brackish environment. Specific items such as the vertical salinity gradient and the relative position of the isohalines were looked at to help identify the amount of mixing occurring in the St. Jean Estuary. Another item of consideration in this study were areas of anomalous salinities and the probable causes of these anomalies.

The original hypothesis that the data was expected to show for the St. Jean Estuary was that as high tide is approached, the salinities near the mouth of the river will increase due to the tidal wedge moving upstream into the estuary and increasing the salt concentrations. Conversely, as low tide is approached the overall salinities are expected to decrease throughout the estuary, but especially near the mouth of the river because the influx of freshwater would now be greater than that of the seawater. To test this assumption measurements of salinities were taken throughout a range of times in the tidal cycle over a four week period.

Methods

In order to measure the salinity, numerous sites throughout the estuary were marked with wooden stakes. These stakes pinpointed a location that could be revisited and remeasured at different times in the tidal cycle and on different days. Twenty stakes were put in along the main deep water channel, and another twenty stakes were placed along four north-south traverse lines across the estuary itself. As many stakes as possible were revisited each day. At each stake, measurements of the salinity at both shallow- about 20 cm- and deep- about 95 cm- water depths, were recorded. Obviously, water depth in an estuary is subject to the changing tides. At low tide it was impossible to take two measurements due to a lack of water depth in most of the estuary.

The salinity itself was read off a salinity meter which detects the amount of dissolved salts in the water by use of an electrical current between two electrodes. The more salts present the stronger the current and a higher reading is shown on the dial. The salinity is read in parts per thousand (°/oo). The salinity measurements for the St. Jean Estuary ranged from 29 °/oo to 0.5 °/oo. As normal seawater is 35 °/oo these salinities reflect the mixing of freshwater, usually less than 0.5 °/oo, with the seawater (Boggs, 1987). Measurements were recorded daily for four weeks in varying atmospheric conditions. Salinities were taken at the traverses for two complete six hour tidal cycles with a reading being taken every thirty minutes. This resulted in data depicting the changes in salinity throughout a tidal cycle. The fluctuations due to tidal influx and river drainage were noted using two stilling wells and a Stevens meter.

The salinity data was correlated to the correct time in the tidal sequence and then was entered into a computer contouring program. This produced a computer generated contour map for five specific tidal settings-- low-tide, mid-tide, high-tide, ebb-tide, and flood-tide stages (fig. 1). These maps were analyzed and interpreted as to the variations of the salinity with changing tides.

Conclusion

Analysis of the gravity data reveals a broad, relatively shallow valley that slopes gently toward the east (Fig. 6). These results indicate that there are no obvious subsurface controls on spit formation, such as glacial moraine deposits in a U-shaped valley.

Reference Cited

Burger, H. Robert, 1992, Exploration Geophysics of the Shallow Subsurface: Prentice-Hall, 489 p.

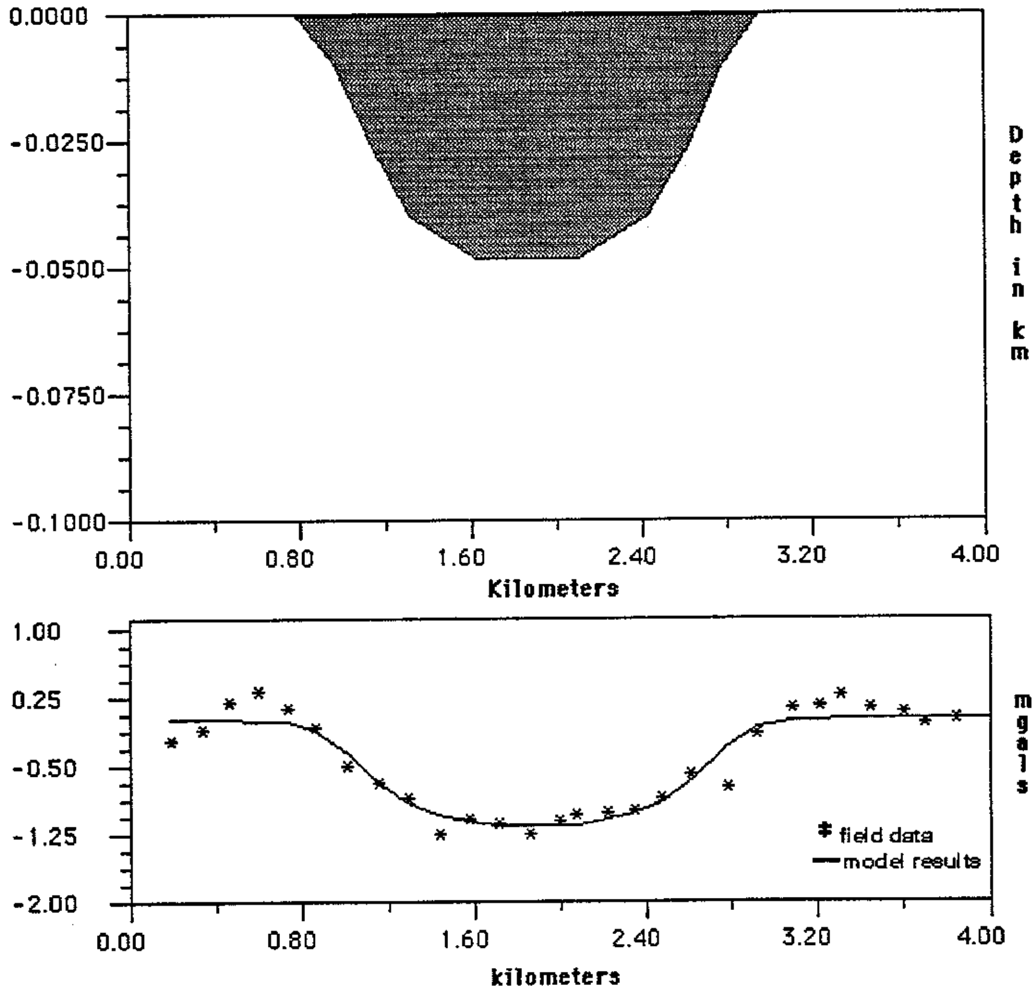

Figure 5. The best-fit model that gives model results most closely following the residual data for the Douglastown and Haldimand Spits and constraints imposed by seismic refraction results.

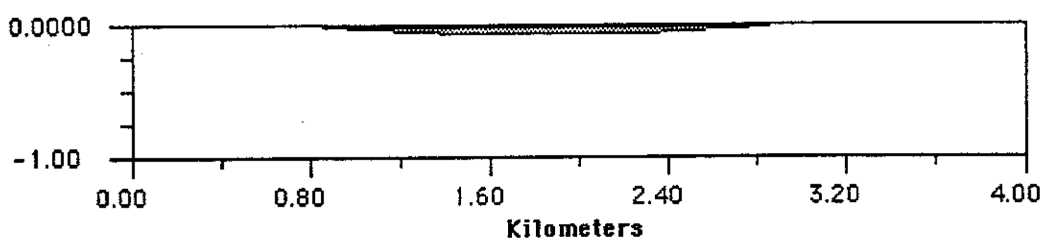

Figure 6. Bedrock profile beneath the Douglastown and Haldimand Spits. This profile is the model illustrated in Figure 5 as drawn with horizontal and vertical scales approximately equal.

Results

The results obtained from the salinity data and contour maps indicate that in the St. Jean Estuary there is a slight reduction in the vertical salinity gradient. For a salt-wedge estuary, which has a pronounced vertical salinity gradient, the deeper water is much more saline due to the denser seawater moving into the estuary along the bottom. While an increased salinity of deeper waters was observed most of the time in the St. Jean Estuary, it was not exclusively the case. At some stakes the salinities at shallow depths were dramatically above those of the lower depths. At still other locations, the salinity showed no change due to depth. These are enough exceptions to consider the St. Jean Estuary to be a partially-mixed estuary.

In a partially- mixed estuary there is a moderate amount of mixing between fresh water and seawater. Isohalines in a partially-mixed estuary are on a diagonal (fig.2). This indicates that the salinities at deeper depths are more saline but that mixing will occur to cause fluctuations in this pattern. A partially- mixed estuary is an environment of moderate energy.

Upon interpretation of the salinity contour maps a few anomalies were observed. Directly off the south shore of the estuary there were low salinity readings. This is most probably caused by fresh water run-off from intermittent streams due to precipitation or by permanent, spring-fed streams. In the area of the St. Jean Estuary the bedrock was located close to the surface as seen in several steep outcrops. This surface bedrock may have been influencing runoff because there is not much soil to absorb the water, and it was forced to drain directly into the estuary itself.

Another unexpected variation observed on the contour maps was that the assumption held before doing the field work that at low tide the overall salinity of the estuary would decrease did not hold true. The same salinities were found at low and high tide but were located in different areas. While there was a decrease of the salinity at the mouth of the river to 2 °/oo as compared with 4 °/oo at high tide, the next salinity interval of 4 °/oo plots farther upstream into the estuary than at high tide. There is a sharper decline of salinities over a smaller area at high tide while at low tide there is a more gradual gradation from high to low salinites. For example at high tide the 14 °/oo salinity contour is located at 64°24′20″ on the south side of the estuary. The 4 °/oo salinity contour also on the south side of the estuary is found at 64°24′35″. There is a sharp decline over the space of 15″ of 10 °/oo salinity. At low tide on the south side of the estuary the 14 °/oo salinity contour is at 64°24′19″ and the 4 °/oo salinity contour is located at 64°24′37″. This is a decline in salinity of 10 °/oo over 18″. While these numbers may not seem too dramatic, it must be realized that the overall shape of the contours between high and low tide varies tremendously. At high tide the contours are basically perpendicular to the shoreline. At low tide the contours are no longer situated in this manner. There are high salinity peaks in the tidal flats and low salinity depressions near the channel. The rest of the contours are spaced between these extremes and situated parallel to the shoreline. These variations indicate that the topography of the estuary and the accumulation of sediments is important in the movement of water throughout the estuary. At low tide anomalies were located around sand bars and the main deep water channel.

References

Boggs, S. (1987) Principles of Sedimentology and Stratigraphy. New York: Macmillan Publishing Company.

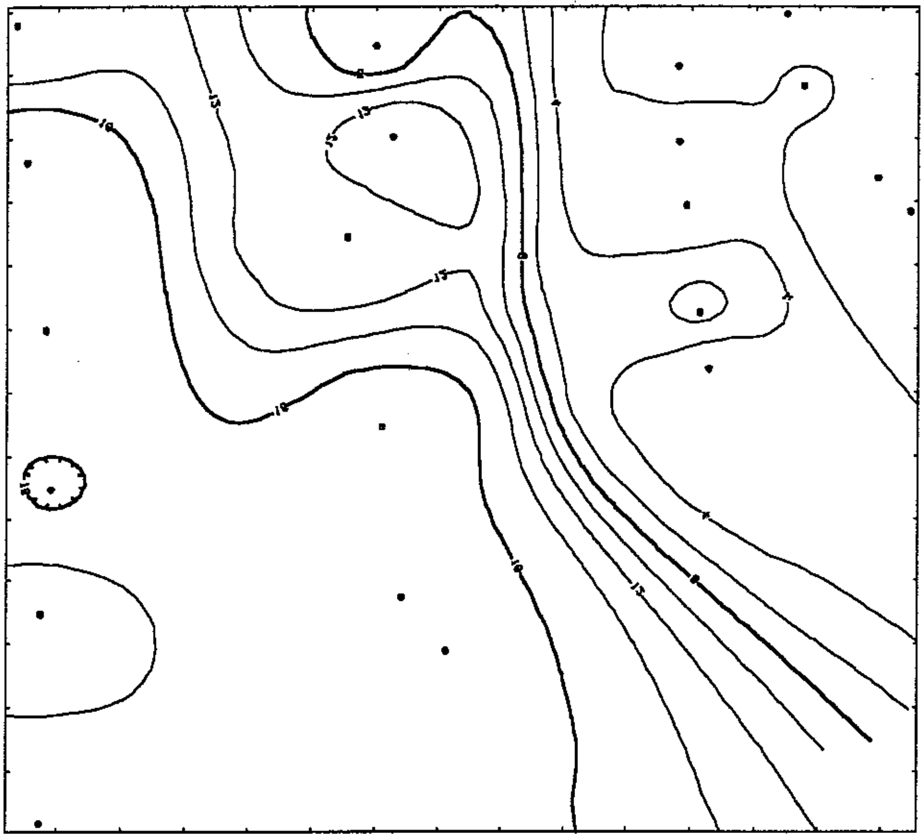

Figure 1. Average salinity contour map

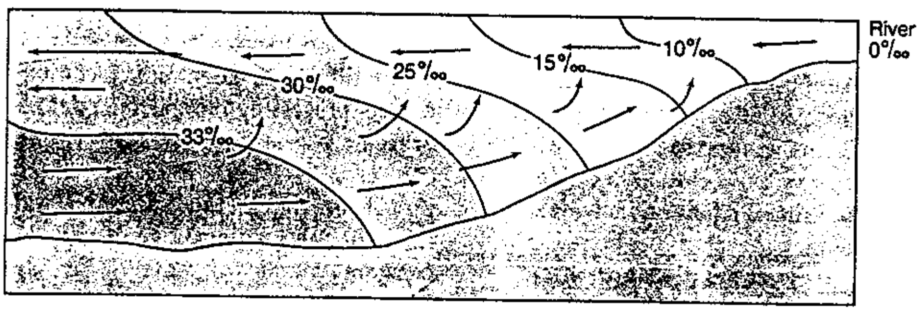

Figure 2. Isohalines in a partially-mixed estuary. (From a handout distributed by William Fox.)