Atlantic Geology

Cobequid Bay Sedimentology Project: A Progress Report

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Volume 8, Number 2, September 1972

URI: https://id.erudit.org/iderudit/ageo08_2rep01

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Publisher(s)

Maritime Sediments Editorial Board

ISSN

0843-5561 (print)
1718-7885 (digital)

Explore this journal

Cite this article

Knight, R. J. (1972). Cobequid Bay Sedimentology Project: A Progress Report. *Atlantic Geology*, *8*(2), 45–60.

Reports

Cobequid Bay Sedimentology Project: A Progress Report*

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Introduction

This report presents some descriptions and preliminary interpretations from field work carried out on intertidal sand deposits in Cobequid Bay, Nova Scotia. The work was a continuation of a field program begun in 1971 to study the mechanics of intertidal sedimentation.

In recent years there has been an increase in the interest of intertidal and tidally dominated areas. Descriptions have emphasized facies subdivision and the internal and external morphologies of bedforms (van Straaten, 1953; Postma, 1957; Evans, 1965; Reineck, 1967; Reineck and Singh, 1967; Terwindt, 1971; and de Raaf and Boersma, 1971). Textural analysis and hydrodynamic considerations have generally received minor attention.

During the past 40 years considerable effort has been expended in theoretical and experimental investigations of fluid flow in the area adjacent to a boundary. These investigations have formulated the general nature of the turbulent boundary layer under steady uniform conditions. The influence of boundary roughness on the flow, the transition from hydrodynamically smooth to rough boundary conditions, the forces necessary to initiate sediment motion, and bedform flow fields have been considered. Natural flows are seldom steady and uniform or both, and few investigators have attempted to test the applicability of experimental and theoretical steady uniform flow results to natural marine conditions. Conditions in the natural environment are more complex, and consequently less understood. Similarly, there has been little attempt to relate hydrodynamics to the sediments in order to explain the occurrence of textural and bedform distributions seen in the natural environment.

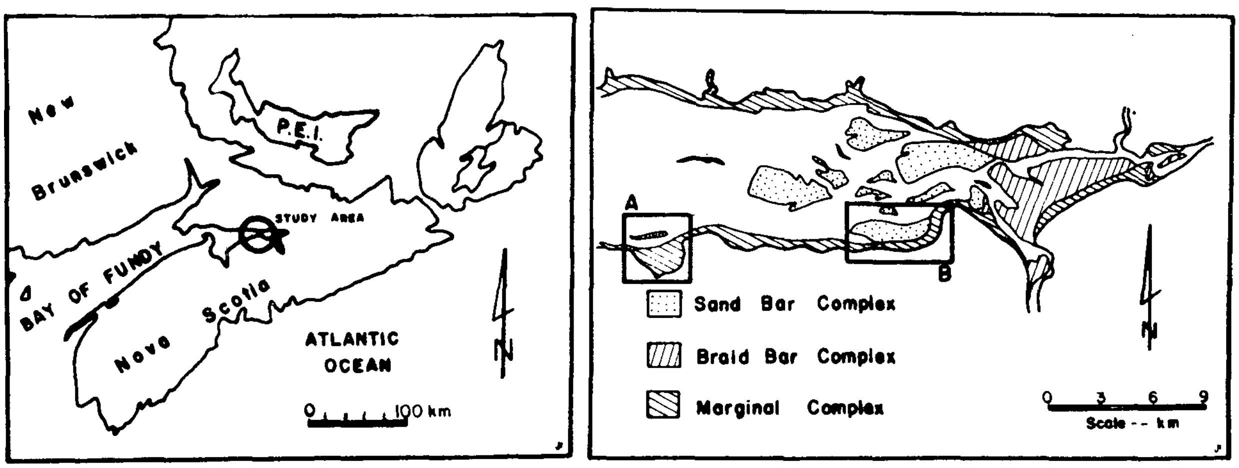

Figure 1: (a) Location of field area; and (b) location of sand bars in Cobequid Bay complex taken from 1963 National Air Photo Library air photos with some modifications (A-Noel Bay Bar and area; B-Selmah Bar and area; East Noel Bar is situated along the shore to the east of A).

Klein (1970) discussed some relationships between sediment textures and hydrodynamics (essentially current velocities and directions) to a facies analysis and description of bedforms found in the intertidal environment along the north shore of the Minas Basin. He attempted to explain the trends which he observed by construction of a depositional model. This approach to understanding the mechanics of intertidal sedimentation is quite reasonable but it can be extended much further by a closer look at sediment textures and water-mass hydrodynamics.

Boothroyd (1969, 1971) and others from the Coastal Research Group, University of Massachusetts, have tried to establish the genesis of some estuarine bedforms and cross-bedding as functions of current velocity, water depth, water temperature, and sediment grain size. The most extensive work at present appears to be that of Sternberg (1966, 1967, 1968, 1969, and 1971) and Kachel and Sternberg (1971). An instrument platform designed at the University of Washington (Sternberg and Creager, 1965; and Sternberg, 1969) was used to study sedimentary processes on the

* Manuscript received December 15, 1972.

continental shelf, to explore which of the possible variables present were improtant in determining the hydrodynamic interactions of the sediment and the fluid flow, and to evaluate previously described relationships between sediment movement and fluid flow using field data. The field data comprised information on velocity distributions (from the bottom to 2 metres above the bottom), sediment distributions, sediment textures, geometry of the sediment water interface (bottom), suspended sediment distributions, and the amount and characteristics of sediment transport.

The area chosen for this study was Cobequid Bay, Nova Scotia (Knight, 1972: Canadian Hydrographic Service (CHS) Chart 4010; Department of Mines and Technical Surveys (DMTS) map sheet 11E/5E, 1:50,000 (Fig. 1). The field area is characterized by a mean semi-diurnal tide range of 11:5 m with a maximum spring tidal range of approximately 17 m (CHS Tide Tables for 1971 and 1972). A tidal range of this magnitude and frequency permits the observation of the sediment responses produced during ebb-flow periods and consequent emergence which are normally inaccessible in other coastal areas due to water depth.

The field project was supported by McMaster University, and the Atlantic Geoscience Centre, Bedford Institute of Oceanography. Three main aspects of study were pursued as follows: (1) the morphology of the intertidal sand deposits; (2) the erosional and depositional events that determine the morphology; and (3) the environmental conditions under which these events occurred.

Field Observations and Work Accomplished

General:

In the 1972 summer field season, Selmah Bar was selected for intensive study for several reasons: to extend observations made in the 1971 field season to other sand bars in Cobequid Bay for comparative purposes; to examine the more complex bedform and topographical relationships found on Selmah Bar; and to provide current measurements to supplement the textural studies being carried out by a co-worker on the same bar. Dalrymple (1972) discusses some preliminary descriptions and interpretations of Selmah Bar from his observations in 1971. About three months were spent by the writer in field work from late May to the end of August, 1972, studying Selmah Bar, Noel Bay Bar, and East Noel Bar (Knight, 1972).

The Launch:

The Bedford Institute of Oceanography provided a 31-foot sounding launch, the 'MALLARD', for use in the 1972 field season. The boat was equipped with two davits with blocks for hauling, two hand winches, and a Raytheon echo-sounder. To keep the launch upright during 'grounded out' periods on the sand bars, two wedge-shaped chocks were secured against the keel during high slack water before current flow began. The launch proved to be satisfactory for the type of field work undertaken in this project, and it was possible to use the boat on a regular schedule throughout the 1972 field season, even during marginal weather conditions.

Weather conditions in late June and July were generally calm and fog-free which permitted a considerable amount of work to be accomplished with the boat. August was very windy (with winds commonly exceeding 25 knots) and foggy. This hampered boat operations and prevented safe grounding out on the sand bars on some days.

Bedform Measurements:

In June, Selmah Bar was resampled on a 300-m grid and bedforms were remeasured. Fifty-five sample/bedform measurement stations were occupied to provide comparative data for the measurements made by Dalrymple (1972) in 1971. Similar measurements and samples were made on East Noel Bar and Noel Bay Bar later in the field season (Table 1). External bedform measurements were the same as those used during the 1971 field season including: wavelength, amplitude, slip face angle, stoss side angle, and strike (Allen, 1963; and Knight, 1972). Photographs were taken at the same time as bedform remeasurements.

Table 1 - Summary of sample/bedform measurement stations occupied during 1972.

Selmah Bar	55 stations	June 14, 15, 16, 28
East Noel Bar	12 "	July 31
Noel Bay Bar	25 "	August 3

Current Measurements:

Two different current meters and techniques were used during the 1972 field season:

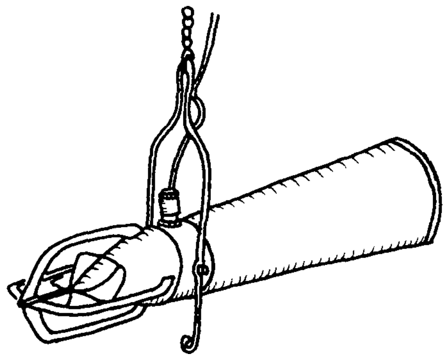

Figure 2: Kelvin Hughes direct reading current meter.

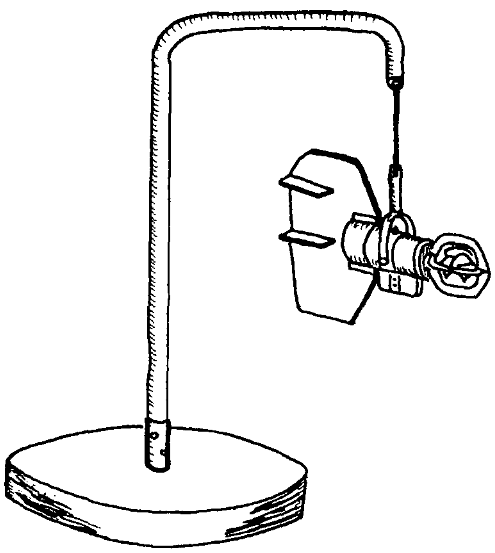

Figure 3: Plessey continuous recording current meter and base. A similar base was used for the 1972 Anderau current meter.

(i) a Kelvin Hughes (Fig. 2) direct-reading current meter (velocity range from 0.1 to 6.0 knots ± 0.02 knots, and direction ± 1.5°). Readings were taken at 30-minute intervals over each tidal cycle (from high water to high water) measuring current velocity and direction along a vertical profile from the seabed at measurement intervals of 0.5, 1.0, 1.5, 2.5 m. .... These current meter stations were established over specific areas (9) on Selmah Bar which displayed different bedforms, slopes, and sediment textures. Each station was occupied two times: once at or near a spring tide and once at or near a neap tide. Station positions were marked by floating elliptical buoys moored by sand-filled burlap bags. The data from these measurements, as with similar 1971 measurements, have been plotted in three preliminary forms: time velocity graphs for velocities at the bottom and surface, current velocity versus depth on semi-log paper, and directional roses (frequency plots per 10° interval per each current profile).

(ii) two Anderau (Fig. 3) continuous-recording current meters (velocity range from 0.1 to 6.0 knots ± 3.0 cm/sec, threshold velocity = 3.0 cm/sec, direction ± 2°, temperature ± 0.025° in the range of -1 to 25°C -- recording is continuous at 30-minute intervals in binary code on magnetic tape). Readings were taken with these current meters secured by a 400-pound circular concrete base with the meter suspended 0.5 m from the bottom on a tubular steel davit fastened to the base. The larger boat used during the 1972 field season made handling of the current meter bases easier but still not without problems. High winds throughout August made recovery of the meters difficult and only successful with the use of SCUBA. One meter base was lost en route to shore during strong winds and could not be relocated even after a day's searching. Calm weather conditions are essential for the safe and efficient deployment and recovery of the bases to these current meters. The two current meters were each located in two different positions on or adjacent to Selmah Bar for periods of approximately one lunar-tidal cycle (spring tide to spring tide). Table 2 summarizes the periods of operation and locations on Selmah Bar.

Table 2 - Anderau current meter periods of operation and location on Selmah Bar, 1972

Meter No.	Dates of Operation	Location
1	June 28 to July 27	A (on bar)
	July 27 to August 15	B (channel)
2	June 28 to July 28	C (on bar)
	July 28 to August 14	D (channel)

Note: see Fig. 14 for meter locations. The data measured by these current meters is stored on tape which can be converted to paper computer tape input.

Suspended Sediment Sampling:

A one litre 'instantaneous', suspended sediment sampler was borrowed from the Sediment Survey Laboratory, Inland Waters Branch, Ottawa. Water samples of approximately 750 ml were collected at the bottom, mid-depth, and surface for periods of high slack water, mid-ebb, low ebb, low flood, mid-flood, and high slack water. A total of 78 water samples was collected on five different days at five separate locations (Table 3) over a lunar-tidal cycle. The samples were placed in glass salinity bottles and injected with a solution of NaN_3 to prevent algal growth. Samples were stored in styrofoam containers and kept in a cool, dark place.

Table 3 - Summary of suspended sediment samples taken in 1972.

Date	No. of Samples	Location (Buoy No.)
July 4	13	2
July 13	16	3
July 19	16	6
July 25	15	5
August 9	18	Channel north of 6

Note: see Fig. 14 for buoy locations.

The water samples will be analyzed for suspended sediment concentration, water specific gravity (water and water-sediment mixture), and viscosity. The techniques to be used are those discussed by Guy (1969) and those in use at the Sediment Survey Laboratory, Inland Waters (personal communication).

Monitoring of Bedform Changes:

This part of the 1972 field program involved two scales of observation: (i) bedform changes over a lunar-tidal cycle; and (ii) bedform changes over a diurnal tidal period.

To measure bedform changes over a lunar-tidal cycle, 5 to 6 steel stakes (measuring 3/8" x 4 to 6') were driven into the crests of bedforms to about 90% of their lengths. The surface of the bedforms were marked by brass wires, and steel washers (i.d. 5/8") were placed over the rods to this level (Clifton, 1969). Four measurements were taken at each stake location at about two-day intervals over a tidal cycle including: crest to stake distance (both ebb and flood crests if both present); distance from the wire to the bedform surface; distance from the washer depth to the bedform surface; and the bedform amplitude (ebb and flood features if both present). About 20% of the stakes used were lost through erosion and/or bedform migration.

During the low tide period of each current-meter station, a Zeiss Ni 2 level was used, supplementing external bedform measurements (Allen, 1963; and Knight, 1972), to survey between two known points perpendicular to the bedform crests. A second survey line along a bedform crestline was used to characterize the plan shape of the bedform. The plan measurement will be used to calculate a 'sinuosity index' (ratio of actual crestline length to the horizontal distance between two end points) to measure and classify bedform geometries when viewed from above. Allen's (1963) plan descriptions (straight, linguoid, and lunate) are useful, but are inadequate for describing different degrees of bedform sinuosity.

These survey measurements were made during periods of spring and neap tide for each station. Descriptive notes and photographs were taken at the same time.

The second scale of monitoring bedform changes used the Raytheon echo-sounder and the launch. On calm days, the echo-sounder was run continuously at fast paper speed and the launch at dead slow speed over different parts of Selmah Bar perpendicular to bedform crestlines during the ebbing tide. It was possible to record the progressive change of bedforms after the current reversal (Fig. 4). It was not possible to make sounding runs on the flood tide because of bad weather

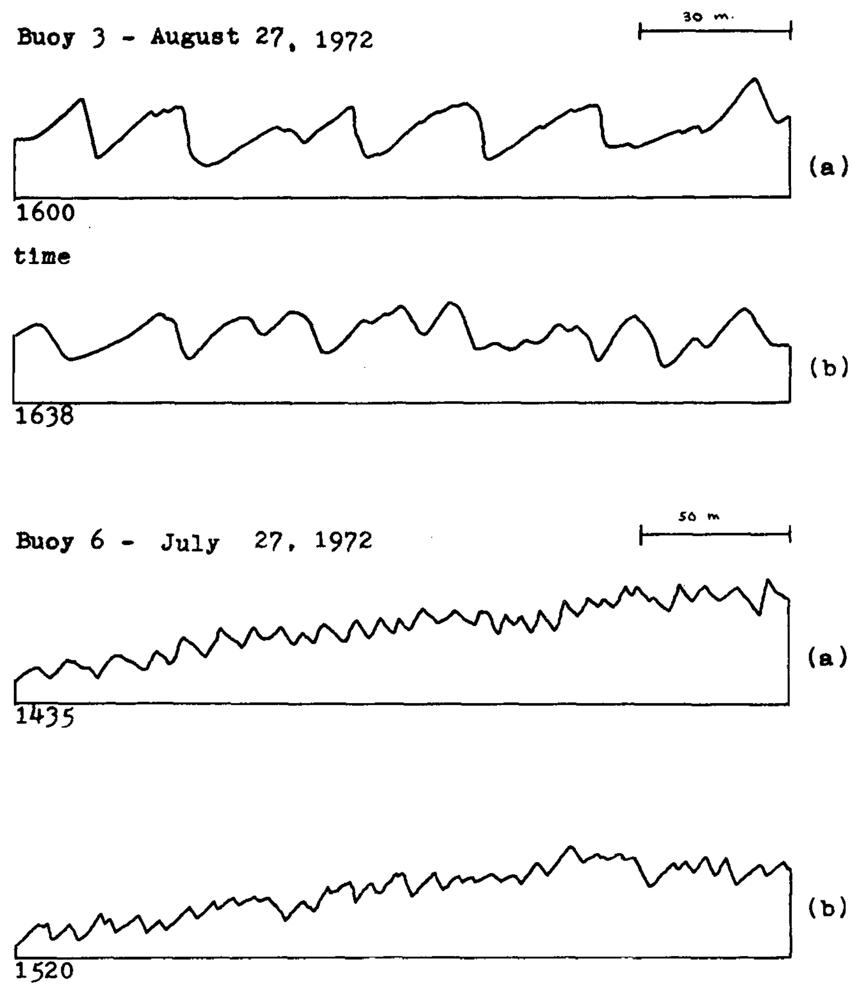

Figure 4: Tracing of sounding record over Selmah Bar -- (a) unmodified flood oriented bedforms; and (b) partially modified flood bedforms. High slack water on August 27 and July 27 was approximately 1515 and 1430.

during the flooding tide (generally high winds during August), and the difficulty of operating the launch in shallow water with rapidly moving currents during the channelized flow stages. If equipment is available and the weather permits, this sounding survey will be continued and expanded in the 1973 field season.

Water Slope Measurements:

A Wilde T2 theodolite was sight onto 7 moored buoys over Selmah Bar to measure water surface slopes at mid-ebb and mid-flood. Slope calculations will be tabulated using the theodolite angular readings and measured horizontal distances from air photographs and sand bar surveys. Results of this survey are not completed.

Trenching and Peels:

Internal structures of bedforms were described and photographed only from trenches in coarse sands. Lack of success in observing internal structures in other sands is outlined by Knight (1972).

Macro-internal structures were preserved on peels using a 3M product, spray adhesive 77. This technique did not preserve micro structures and was successful only in medium to coarse sands; therefore, it was not extensively used.

Air Photographs:

No oblique air photographs were taken during the 1972 field season because of the working schedule and weather conditions.

Approximately 200 vertical air photographs were flown on contract to Atlantic Air Survey at an elevation of 7670 feet between 1630 and 1750 ADT on July 22, 1972. These photos were flown about three days after a neap tide period during an ebbing tide (about 30 to 45 minutes before dead low water). The scale is approximately one inch to 1320 feet. The photos will be used for mapping areal facies and bedform distributions, comparing sand bars in the Cobequid Bay complex, and charting progressive changes of the sand bars relative to earlier air photos (National Air Photo Library 1938, 1947 and 1963).

Completion of the Project

Four stages of work will be necessary to complete this project:

1. Field Work - Two further field trips will probably complete the field work: a week of study in late February, 1973, to observe winter conditions; and a final summer field season in 1973. The summer work will emphasize internal structures of the bedforms (peels), diurnal bedform changes, oblique air photos and general photos, and wave descriptions. If time allows, some work will be done on the mudflats.

2. Laboratory Analysis of Field Samples - Laboratory work includes: suspended sediment concentration, some grain size analysis of suspended sediments, specific gravity measurements, and viscosity measurements. The suspended sediment samples collected in 1971 will be analyzed if a low temperature asher is available. Hopefully most of this work will be completed before the 1973 summer field season.

3. Reduction and Analysis of the Data - This is the bulk of the project: construction of base maps; plotting of graphs; compilation of various surveys; and the writing of computer programs to derive hydraulic parameters and summarize current data.

4. Compilation of the Final Report - The study will be initially presented in the Department of Geology, McMaster University, as a degree dissertation, and to the Atlantic Geoscience Centre, Bedford Institute of Oceanography, as a government report during 1974.

Preliminary Interpretations and Discussion

General:

The distribution of sediments, bedforms, and the geometry of the sand bars can be related to the hydraulic regime found in the environment. Only preliminary interpretations and discussions are possible as the field data are still being compiled.

The bedform measurements made on Selmah Bar during June are similar to those measurements made in 1971 by Dalrymple (1972). The bedform measurements made on East Noel Bar and Noel Bay Bar in 1971 are also similar to those made in 1972. Selmah Bar presents the widest variety of bedforms and diversity of topographic relationships (Dalrymple, 1972). The complex topographic relationships on Selmah Bar and to the adjacent shore, the sand bar exposure to ebb-flood tidal currents, and wave activity seem to be responsible for the observed variety of sedimentary relationships.

The sequence of bedforms with increasing current strength, outlined by Knight (1972) from other sand bars in Cobequid Bay, exists on Selmah Bar with one further inclusion - sand waves:

```
                                          sand waves

linear   →  lunate-linguoid  →  linear        →  scour        →  planed-off
ripples         ripples         megaripples      megaripples      megaripples
                                                                      ↓
                                                            plane bed
```

Sand waves (wavelengths of 35 m and amplitudes of 100 cm) occur only as flood oriented bedforms with smaller superimposed ebb oriented megaripples on Selmah Bar. The bar topography and position relative to Salter Head leaves this area exposed to flood tidal currents which "funnel up" a low area from the west between the shore and the sand bar. Strongly flood-dominated bedforms result (Dalrymple, 1972) with smaller superimposed ebb oriented bedforms.

Megaripples (wavelengths from 1 to 4 m and amplitudes from 10 to 30 cm) on Selmah Bar are dominantly ebb oriented at low water emergence, since the last current to pass before emergence was ebb in direction (to the west). The bedform slip faces are oriented to the west. Echo-soundings during the ebbing tide indicate that many of the bedforms, which are ebb oriented during low water, become flood oriented during the flood phase of the diurnal tidal cycle. There is a successive modification of the bedforms on the sounding records as the tide progresses from high slack water towards low water (Fig. 4). Individual bedform crests could be recognized and measured

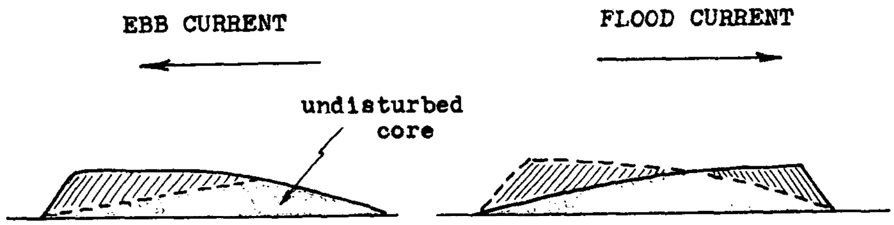

Figure 5: Diagrammatic sketch of the effects of ebb and flood currents on the same bedform.

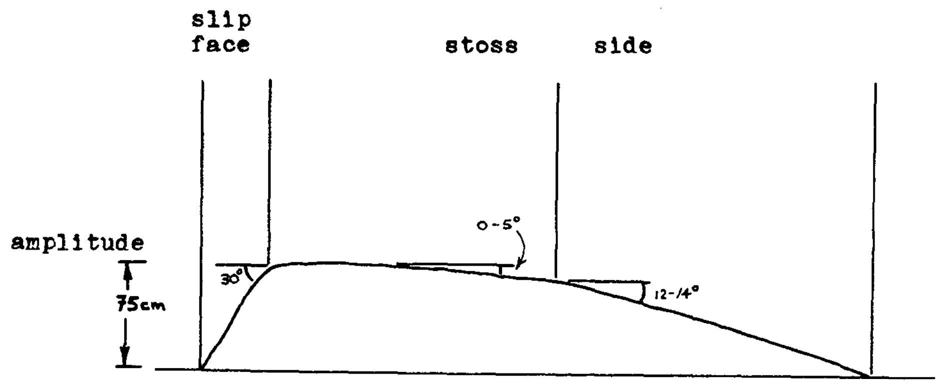

Figure 6: Straight crested megaripples at buoy 6 which distinctly display two stoss-side angles.

for migration rates at low water on successive days. These observations suggest that tbe bedforms are only modified by successive tidal currents and that the central part of the bedform is undisturbed in the short term (Fig. 5). These bedform cores may become redistributed due to net migration over long time intervals. Large straight crested megaripples (with some planed-off crests) at buoy 6 showed two distinct stoss-side angles (Fig. 6). The steeper of the two angles on the stoss side of the bedform may be the modified remnant of a flood-oriented slip face. No internal structures were seen during trenching to confirm this idea.

Possible evidence of flood bedform remnants were seen on Noel Bay Bar (west central end) and in the area of buoy 5 on Selmah Bar. In these areas the currents are flood dominated because of ebb shielding from positive topographic areas lying to the east. The megaripples show small ebb-oriented crests with some double angles on the stoss sides (similar to those in Fig. 6), and a flood oriented stoss side remnant (Fig. 7). This morphology exists only during the period of increasing tides towards a spring-tide period. It is gradually obliterated towards a neap-tide period, and is replaced by an irregular, rippled bed overlying discontinuous linear positive areas (3 to 4 cm high) which are possibly ebb-modified flood crests.

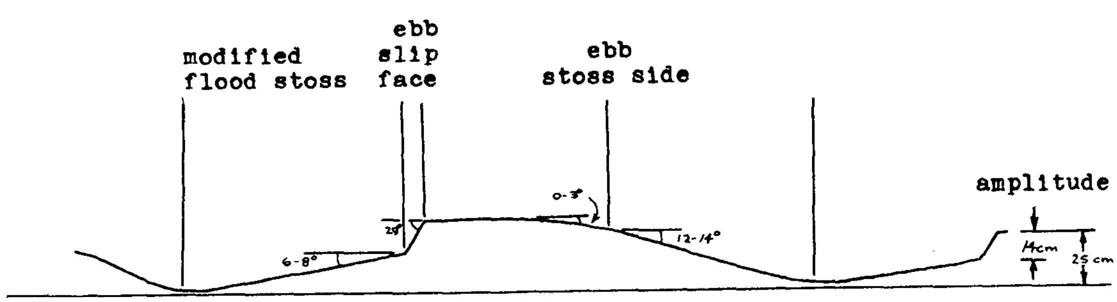

Figure 7: Megaripples in the area of buoy 5 on Selmah Bar which display a possible flood oriented stoss-side remnant.

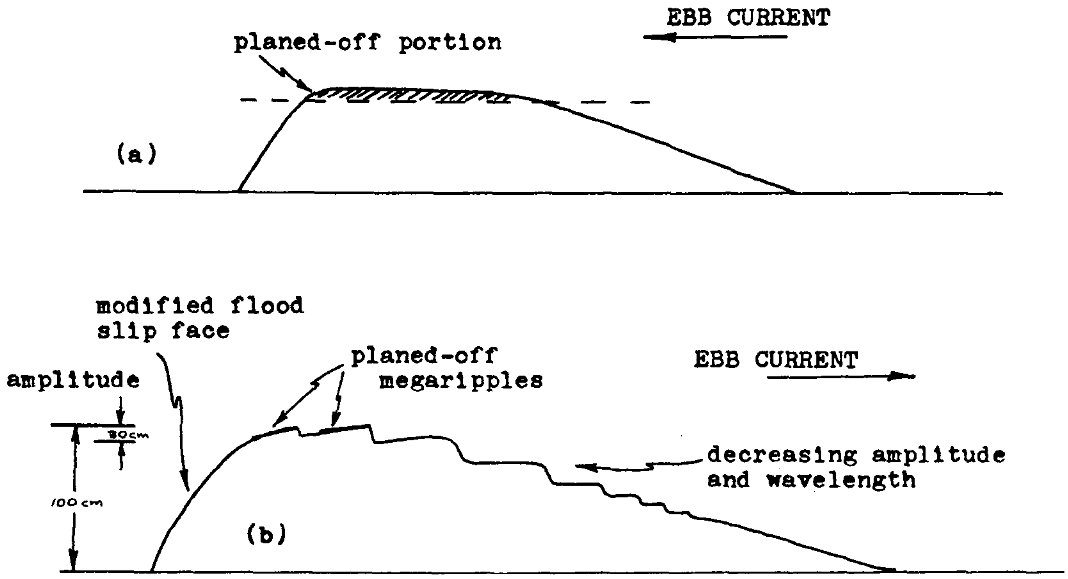

Figure 8: (a) Diagrammatic sketch of planed-off megaripple; and (b) diagrammatic sketch indicating the occurrence of planed-off megaripples on the crest of flood oriented sand waves.

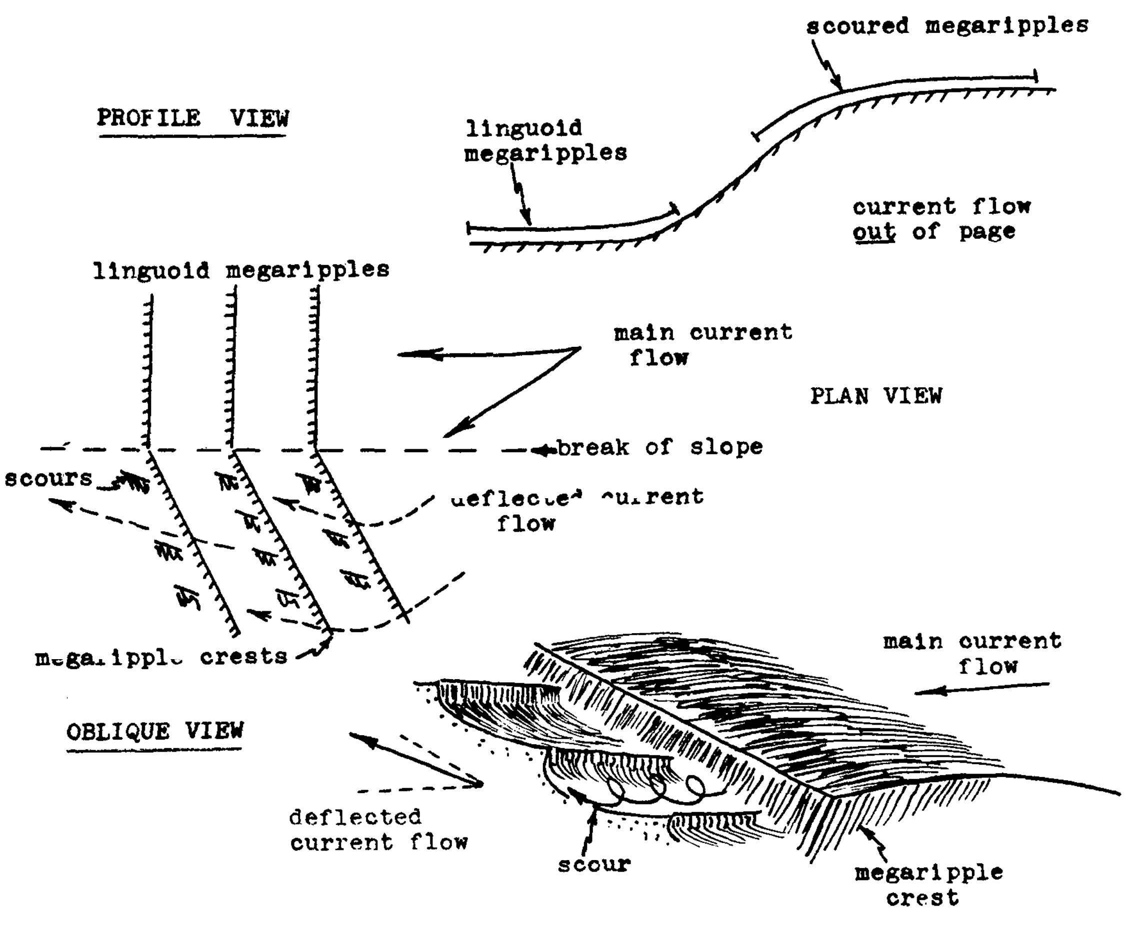

Figure 9: Diagrammatic sketch of the occurrence and the form of scoured megaripples found along the north side steep slope on Selmah Bar.

The flood-oriented sand waves when observed from above are straight or lunate. The ebb-oriented megaripples are straight to sinuous, three-dimensional forms. The varied configurations of the bedform plan appear as the result of a complex interaction between current velocity, slope, grain size, bed load, water depth, current direction, and length of time for formation.

Large linguoid ripples occur at the base of the steep slope along the north side of Selmah Bar. In areas where the current has been forced to move up and over topographical highs, planed-off megaripples form during intervals of shallow water on both ebb and flood tides. Topographically high areas arise from local, bar topography and from large sand waves (Fig. 8). The planing-off of the bedforms is caused by accelerated shallow-water flow over bedform crests (a result of converging flow streamlines due to local changes in water slope).

Scoured megaripples are formed in areas where the mean current flow is deflected by local bar topography and by the presence of megaripple crests (Allen, 1968). Deflection of current flow occurs during the ebb tide along the steep slope on the north side of Selmah Bar. At low water levels the mean current flow is deflected approximately 30° from the dominant current flow direction, and a series of repetitive helicoidal eddies are formed which scour the troughs of megaripples. The asymmetrical shape of the scour cross sections indicates that the eddies flow in a counterclockwise direction, and the longitudinal profiles of the scours coincide closely with the recorded current directions (Fig. 9).

Plane beds occur along the north side, steep slope on Selmah Bar and along the south side, steep slope of Noel Bay Bar. The presence of plane beds on the steep bar slopes is due to the combined activity of tidal currents and waves. Converging and diverging current flow over and around a sand bar as the tide rises or falls may account for the maintenance of the steep slopes (Fig. 10). Wave activity is possibly the most important process if the conditions of slope

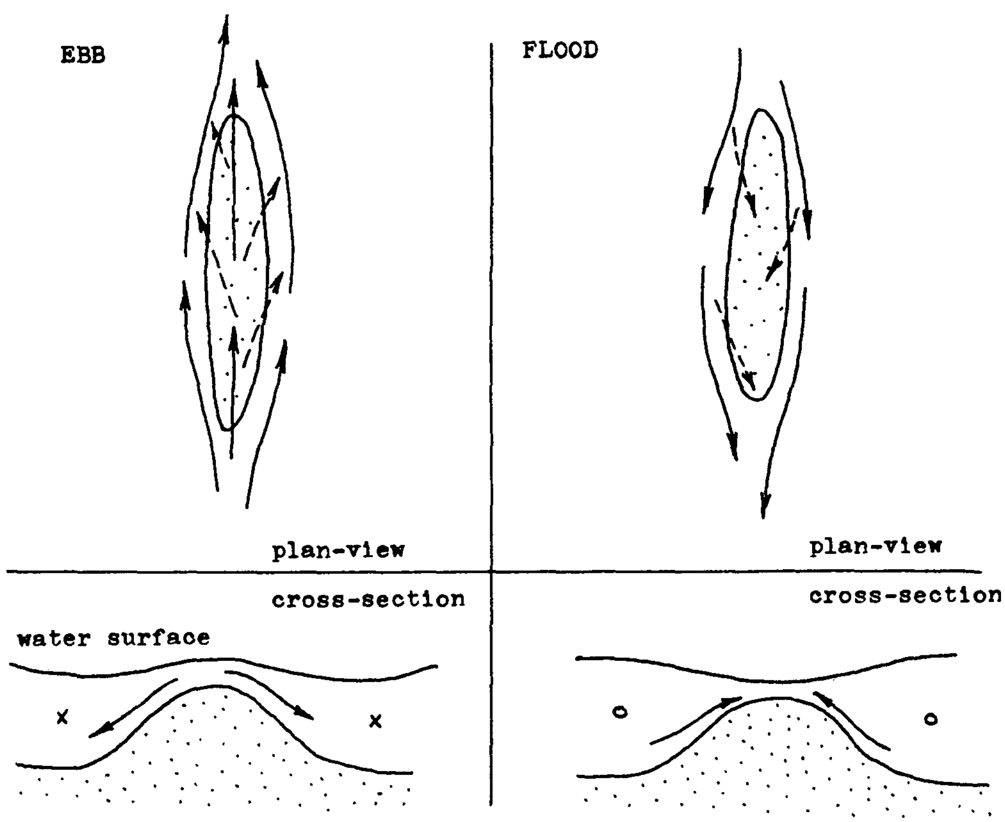

Figure 10: Current flow over and around a sand bar during late ebb and early flood phases (x- main current flow into page ; and o - main current flow out of page).

orientation, slope angle, water depth, wind direction and velocity, fetch, and duration are just right. A combination of current and wave activity may also be necessary. The steep slope on Selmah Bar is exposed to strong wave action by its position, but the steep slope on Noel Bay Bar is partially protected by the shore and the orientation of the sand bar. The apparent opposition of steep slope occurrences between the two sand bars suggests that different orders of process magnitude and frequency must be active, or simply, different processes. The steep-slope position on Selmah Bar is exposed to less frequent, but strong wave attack with tidal current action. Noel Bay Bar, however, undergoes frequent small wave activity with tidal currents. Steep slopes with plane beds appear to result from three possibilities: (1) infrequent, but strong wave attack with tidal currents; (2) frequent, but small wave activity with tidal currents; and (3) tidal current circulation over and around the sand bars.

Ripple bedforms are dominantly superimposed on megaripples and sand waves. The variety of orientation shown by ripples can be related to the local current, wave, and low water trough-channelized flow. Linguoid ripples are generally found oriented parallel or at 10 to 12° oblique to the crests of the superimposed megaripple. Linear ripples occur in megaripple troughs perpendicular to their crests, in megaripple scours, and on the lower stoss-side slopes of megaripples. Ripple crests are frequently bent at some locations as a result of deflected currents over megaripple crests as water levels fall.

Currents:

Some of the current data has been compiled from the continuous recording current meter used during the 1971 field season (Knight, 1972). Table 4 gives a summary of operational dates and locations.

Table 4 - Summary of Plessey Current Meter periods of operation and location on Noel Bay Bar, 1971.

Dates of Operation	Location
July 7 to July 19	Channel, south side of Noel Bay Bar
July 19 to August 1	Channel, north side of Noel Bay Bar
August 1 to August 19	On top of Noel Bay Bar

Note: see Fig. 13 for current meter locations.

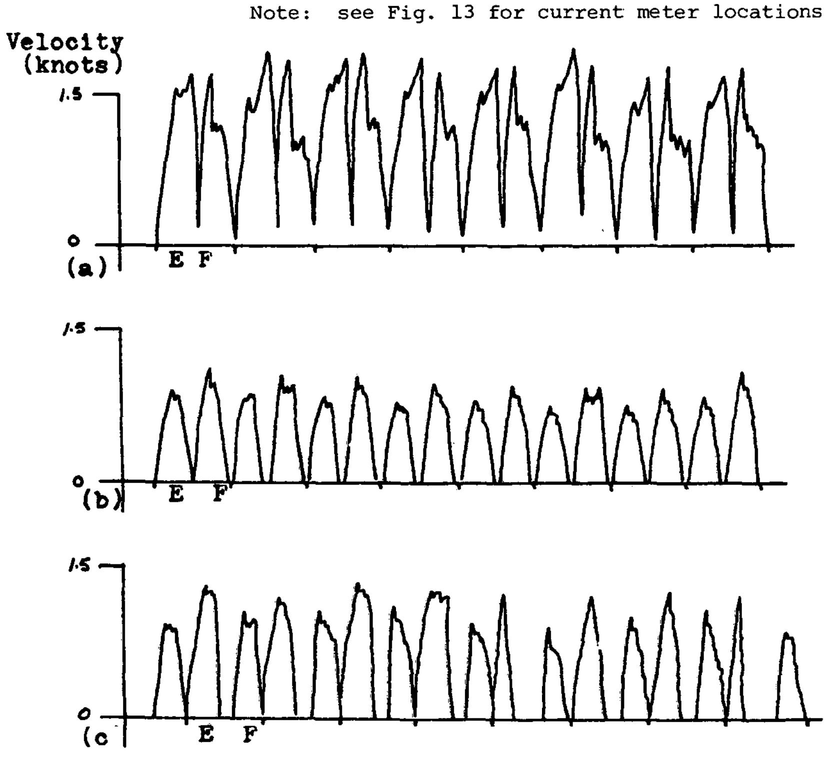

Figure 11: Tracings from portions of the continuous line printout of current velocities versus time recorded with the Plessey current meter in 1971 -- (a) channel south of Noel Bay Bar; (b) channel north of Noel Bay Bar; and (c) on top of Noel Bay Bar. E-ebb current; F-flood current.

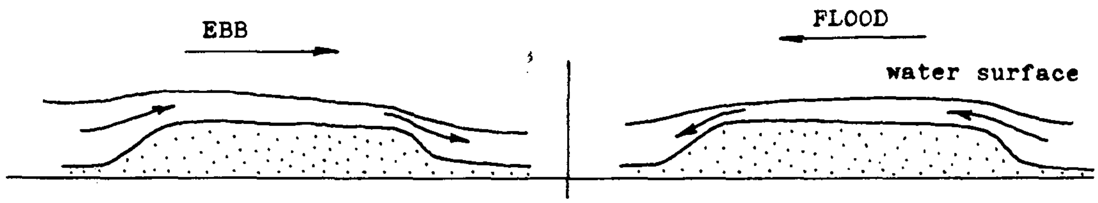

Figure 12: Current flow over the longitudinal section of a sand bar.

A continuous line printout (Bedford Institute computing services) of current velocities and directions versus time from the 1971 continuous current-meter operations is similar to a graph of tidal ranges versus time for the same period (Fig. 11). The greater current velocities recorded at spring tides are required to move the larger volume of water. Conversely, there is a smaller volume of water to be moved within the same time period during the neap tide, so current velocities are less.

Difficulties in the operation of the continuous recording current meter over the sand bar makes the results incomplete. The meter could only operate for three or four days at a time on the bar before the instrument became entangled in its mooring ropes. The current data recovered is useful only for the three or four days after the meter was freed. The record can, however, be used for limited amounts of information about the current flow over the sand bar.

Time velocity relationships in the two channels indicate similar asymmetries. Maximum current velocities occur late in the ebb tide and early in the flood tide. The progressive lowering of water levels and increased friction over the sand bars cause an increase in the water surface slopes between the sand bar and the adjacent channels, and a confining of the current flow within the channels (decreased cross sectional area in direction of flow causes a flow acceleration). Figures 10 and 12 show the converging and diverging of currents over and around sand bars as a result of water-surface slope differences. The progressive lowering of the water level until a sand bar is emergent causes currents to become channelized and confined to either side.

Time velocity relationships over the sand bar are not as asymmetrical as those in the channels. The relationship appears more symmetrical than asymmetrical at some periods. The difference noted between the channels and the sand bars is due to relative position. Flow on the sand bars is not as confined as flow in the channels. Consequently, the sand bar locations record their maximum current velocities earlier during the ebbing tide and later during the flood tide. This causes the sand bar time-velocity relationships to appear more symmetrical.

A difference in magnitudes of the current velocity occurs between the three locations listed in Table 4. The channel to the south of Noel Bay Bar has higher velocities than the channel to the north, which is higher than those velocities recorded on the sand bar. The south channel is narrow (a few hundred metres), and the north channel is approximately 7 miles wide. The sand-bar location does not experience channelizing so current velocities recorded are not as high as those recorded in the channels. The magnitude of the current velocities and the degree of time-velocity asymmetry in the three locations is a function of the degree of flow confinement experienced at each location (through topographic control with falling or rising water levels) and water surface-slope changes.

Similar patterns of time velocity asymmetry are seen in the direct reading, current meter readings. Channel measurements are strongly asymmetrical relative to sand bar locations, and current velocities are of a greater magnitude in the channels.

Table 5 and Table 6 show some readings taken with the Kelvin Hughes direct reading current meter during the 1971 and 1972 field seasons. There is a decrease in current velocities between spring and neap observations. The tidal heights recorded in the tables are from St. John (CHS Tide Tables, 1971 and 1972), New Brunswick. Tidal ranges in the field area are greater. This information is presented to give some relative idea of tidal ranges versus recorded tidal current velocities.

Current profiles on semi-log paper do not plot as smooth lines (Fig. 15). The most reasonable explanation is possibly the occurrence of macro-turbulence. Similar variations are noted in current-direction deviations recorded with each profile measurement.

Current directions are affected by water depth and subsequent topographic control by the sea bottom. This is particularly evident over steep topographic features. Recorded currents move up-slope. Bedforms exposed at low tide are oriented perpendicular to the current flow. The orientations of the megaripple and sand-wave crestline generally coincide with the mean current, flow directions.

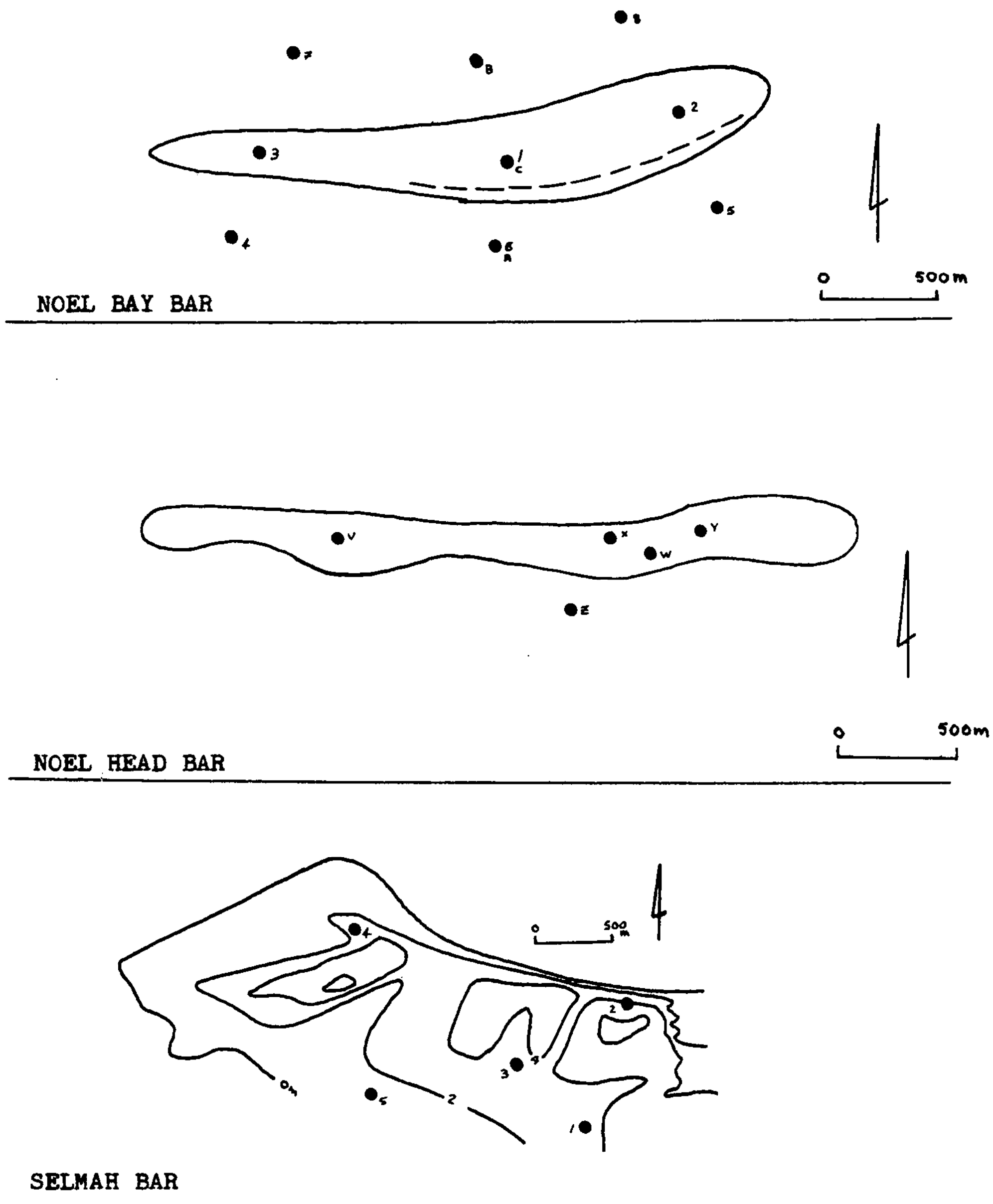

Figure 13: Current meter station locations in 1971. Lettered stations on Noel Bay Bar indicate continuous recording current meter locations.

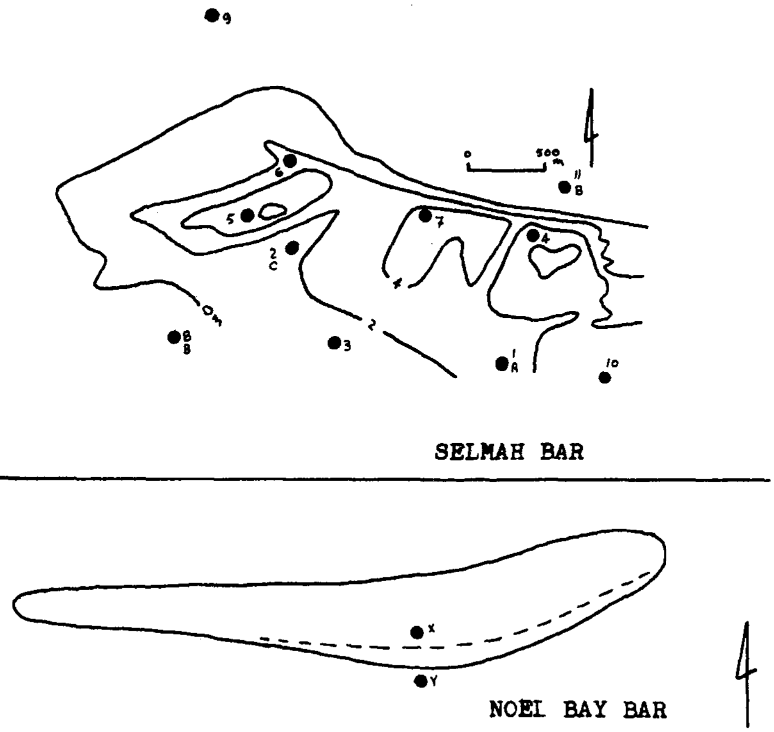

Figure 14: Current meter station locations in 1972. Lettered stations on Selmah Bar indicate continuous recording current meter locations.

Table 5 - Representative current readings from the Kelvin Hughes direct reading current meter, 1971.

Location	Date	Max. Bottom Velocity in Knots (Surface)		Bedform	Tidal Range (in feet)	
		EBB	FLOOD	l. = large s. = small p.o. = planed off	High Water	Low Water
NOEL BAY BAR (on bar)						
1	June 14	1.20 (2.50)	1.75 (1.80)	med. ebb	25.1	2.8
	" 18	1.32 (2.02)	1.20 (1.58)		24.5	3.4
	July 16	1.30 (1.90)	1.25 (1.54)		24.3	3.4
2	June 6	1.42 (2.22)	2.00 (2.25)	s. ebb & p.o. ebb	24.8	3.1
	July 7	1.62 (2.15)	1.45 (2.42)		25.7	2.0
3	" 3	1.12 (1.50)	1.02 (1.20)	med. to l. ebb	21.1	7.0
	" 5	1.00 (1.68)	1.02 (1.34)		21.5	6.5
(channel)						
4	" 12	1.80 (2.55)	1.50 (1.80)		26.2	1.5
5	" 13	1.10 (2.22)	1.05 (1.80)		26.1	1.6
6	" 19	1.10 (1.83)	1.05 (1.53)		23.7	4.1
7	" 22	1.50 (2.10)	1.40 (2.25)		25.2	2.8
8	" 23	1.45 (2.23)	1.60 (2.50)		25.2	2.8
EAST NOEL BAR						
	" 29	1.16 (1.63)	1.00 (1.83)	med. ebb	22.2	5.5
NOEL HEAD BAR						
V	Aug. 10	1.72 (2.44)	2.10 (2.80)	s. ebb	27.1	0.5
W	" 12	1.60 (2.47)	1.70 (2.60)	med. ebb	25.8	1.8
X	" 13	1.70 (2.20)	1.95 (2.41)	s. ebb	24.7	2.9
Y	" 14	1.70 (2.25)	1.67 (2.32)	s. & p.o. ebb	23.6	4.1
Z	" 17	1.35 (2.30)	1.42 (1.68)		22.4	5.3
(channel)						
SELMAH BAR						
1	" 2	0.92 (1.06)	0.87 (1.35)	l. flood (s. ebb) p.o.	21.3	6.7
2	" 4	1.05 (1.42)	1.10 (1.25)	med. flood (s. ebb) sc. & p.o.	22.5	6.2
3	" 5	1.03 (1.45)	1.65 (1.62)	s. ebb & flood	22.9	5.6
4	" 6	1.09 (1.65)	1.58 (2.31)	l. ebb (some p.o.)	23.5	4.9
5	" 7	2.41 (3.42)	2.67 (3.69)	l. flood (s. p.o. ebb)	24.2	4.0

Table 6 - Representative current readings from the Kelvin Hughes direct reading current meter, 1972.

Location	Date	Max. Bottom Velocity in Knots (Surface) EBB	FLOOD	Bedform 1. = large s. = small p.o. = planed off	Tidal Range (in feet) High Water	Low Water
SELMAH BAR						
1	July 11	1.30 (1.42)	1.80 (2.00)	1. flood, s. ebb & p.o.	27.4	1.0
	" 18	1.14 (1.32)	1.50 (1.64)		22.5	5.7
2	" 4	1.32 (1.78)	1.62 (2.52)	s. ebb	24.3	3.8
	" 28	1.74 (2.04)	1.96 (2.90)		25.8	2.3
3	" 13	1.26 (1.62)	1.56 (2.30)	1. flood, s. ebb & p.o	26.9	1.4
	" 20	1.26 (1.52)	1.30 (1.90)		21.3	7.0
4	" 7	0.88 (1.12)	1.12 (1.63)	med. flood, s. ebb, p.o. & sc.	24.1	3.7
	" 22	1.64 (1.64)	1.54 (1.60)		21.5	6.8
5	" 6	0.92 (1.47)	2.00 (2.58)	s. ebb	23.9	3.9
	" 21	0.96 (1.34)	1.60 (1.90)	rippled bed	21.2	7.1
6	" 12	2.08 (2.90)	2.34 (3.56)	1. ebb	27.3	1.0
	" 19	1.50 (2.16)	2.16 (2.34)		21.8	6.5
7	" 5	1.42 (1.88)	1.22 (1.82)	med. scour ebb	24.0	3.9
N steep slope	" 17	2.18 (2.76)	1.70 (2.32)	linguoid & scour ebb	23.5	4.8
Channel 8	" 25	1.26 (1.96)	1.48 (2.00)		23.3	5.0
	Aug. 8	1.30 (1.74)	2.06 (2.20)		23.1	5.1
9	" 9	1.90 (2.72)	2.00 (3.44)		26.5	1.5
east end of bar 10	" 10	0.66 (0.84)	1.48 (1.66)	med.-1. flood	25.4	2.5
Channel 11	" 14	2.00 (2.40)	1.30 (1.44)		24.1	4.3
EAST NOEL	" 1	1.54 (2.02)	1.72 (1.96)	med. ebb	24.8	3.1
NOEL BAY BAR						
X	" 3	1.60 (2.18)	1.26 (1.44)	s.-med. ebb	23.6	4.2
Y	" 4	1.34 (1.86)	1.56 (1.76)		23.3	4.4

Tidal currents are the most important agents of sediment transport in the intertidal environment, but the effects of wave activity may have significant effects. Further study of these aspects is planned.

Water samples collected for laboratory analysis show a visual increase of the amount of suspended sediment towards low tide during an ebb period, and a decrease in the amount during the flood tide towards high water. Concentration analysis should confirm this and provide some figures to fortify this observation.

Conclusions

The complex relationship between hydrodynamics and sediment is immediately evident from this research project. Some preliminary conclusions from the discussions in this report include: more field work is required to observe winter conditions in the field area; more information is required on internal structures, wave activity, and diurnal changes of bedforms; there appears to be a bedform hierarchy related to increasing current velocities; the variety of bedforms on Selmah Bar appears to be a function of the complex topographic relationships, grain size, and exposure to the various processes active on the sand bar; the occurrence of ebb-oriented bedforms at low tide is not necessarily conclusive evidence for ebb dominance; the presence of possible ebb-modified flood features should be confirmed through more extensive study on internal structures; the effectiveness of wave activity on the form and role in sediment transport is not known due to the lack of information; orientations of megaripple and sand-wave crestline appear to be controlled by the mean current direction; small scale ripple-crest orientations appear to be controlled by local shallow-water flow conditions; the magnitude of current velocities and the degree of time-velocity asymmetry is a function of location, point in the lunar-tide cycle, and water surface slopes; irregularities in velocity profiles and directional data suggest the presence of

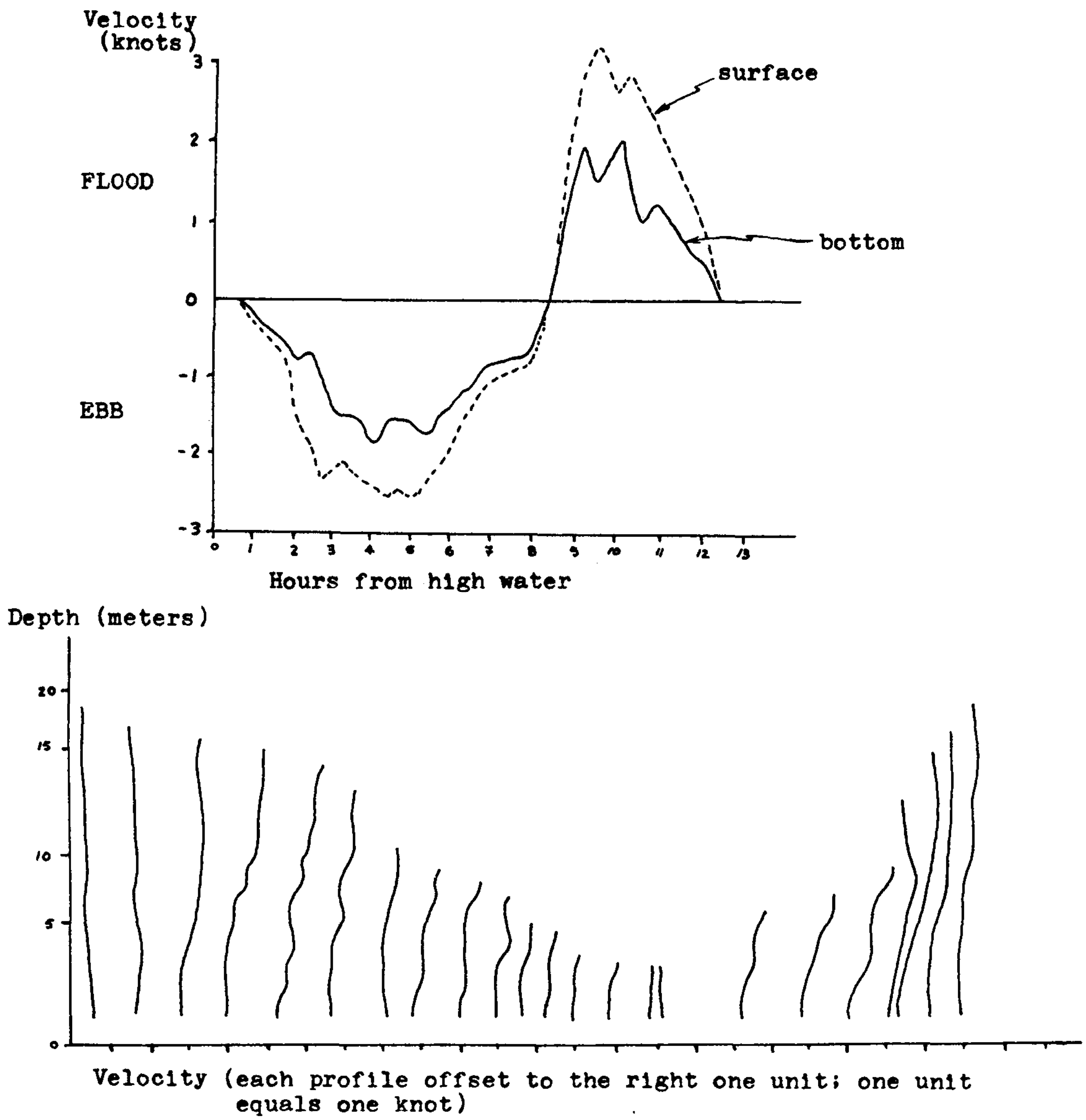

Figure 15: (a) Time-velocity diagram for channel north of Selmah Bar; and (b) successive profile measurements of current velocities recorded at 30 minute intervals in the channel north of Selmah Bar.

turbulence; tidal currents appear to be the most important agent in the transport of sediment in the intertidal environment.

Acknowledgements

This research project, which is part of a degree requirement, is being conducted under the supervision of Dr. G.V. Middleton. Appreciation is expressed to the Atlantic Geoscience Centre, Geological Survey of Canada, at the Bedford Institute, and its various personnel for financial and logistical support during the 1972 field season. Particular appreciation is extended to Dr. B.R. Pelletier for his interest and guidance in affairs at the Institute and with the field program. The principal field assistants during the 1972 field season were Michael Beattie (McMaster) and John Pellerin (cockswain from AOL, Bedford Institute). Tak Chi Yu (McMaster) and Robert Dalrymple (McMaster), who were engaged in other studies in the area, provided some assistance from time to time.

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