SOME FIELD TECHNIQUES USED IN A STUDY OF TAURANGA HARBOUR

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SUMMARY: A summary of the main field methods of research used in a sedimentological study of part of Tauranga Harbour is presented. The research concentrated on the tidal inlet which is the entrance to the Port of Tauranga. SCUBA divers have carried out direct observations of the sea bed and installed various monitoring devices. Sediment sampling programmes posed problems which were largely overcome by using a dredge-type sampler. Tidal currents in the boundary layer were measured one metre above the harbour floor at a number of monitoring stations. Direct measurements of sediment discharge have been made with various devices which trap mobile sediment. Studies of tidal bedforms of both ripple and megaripple scale have been carried out. These investigations have provided a picture of sediment transport processes and patterns near the entrance to the Port of Tauranga.

INTRODUCTION

A sedimentological study of part of Tauranga Harbour has been carried out by the author during 1974-75. The aim of the research was twofold:

1. To study the hydrodynamics and sediment characteristics of the harbour and thus determine what sediment transport processes are operative in the study area.
2. To estimate quantitative rates of sediment transport near the Tauranga Inlet.

Tauranga Harbour is a coastal lagoon impounded by a sandy barrier system of two tombolos and a barrier island (Fig. 1). The barrier system has formed across the mouth of the Tauranga Depression (Shaw and Healy, 1962) in response to the Holocene sea level rise (Healy and Davies-Colley, 1974). The harbour has two natural tidal inlets, one at each end of the barrier island. The southern inlet is the entrance to the Port of Tauranga and it was on this area that the detailed research was concentrated.

The study programme involved underwater observations and mapping by divers, sediment sampling, direct monitoring of tidal currents and sediment movement and study of the harbour bedforms. The following account describes some of the main field techniques used in this research.

SCUBA DIVER OBSERVATIONS

The study area as shown in the map is mainly subtidal and hence direct subaerial observation of the harbour bed is impossible even at low tide. However, extensive direct observations have been made by divers. In this study divers have carried out the following research work:

1. sampling of harbour floor sediments
2. photography
3. surveys of some large tidal megaripples
4. mapping of bedforms
5. installation of tidal current meters
6. installation of sediment traps
7. observations of sediment flow processes underwater.

Turbidity of the harbour waters was a problem during the field research programme, especially after heavy rain and at low tide when murky water discharged by rivers flowing into the harbour intruded into the study area. At high tide, clear seawater replaces the turbid water allowing underwater photographs to be taken.

A major hazard in field operations involving SCUBA diving was the presence of strong tidal currents flowing near the harbour entrance. For most purposes diving operations had to be limited to about thirty minutes of slack water at high or low tide. However some significant observations of processes of sediment flow with acceleration of the tidal streams over large-scale ripples have been made on "drift-dives" at mid-tide.

SEDIMENT SAMPLING

Sixty-eight sediment samples were taken from the study area for textural analysis. Textural parameters,

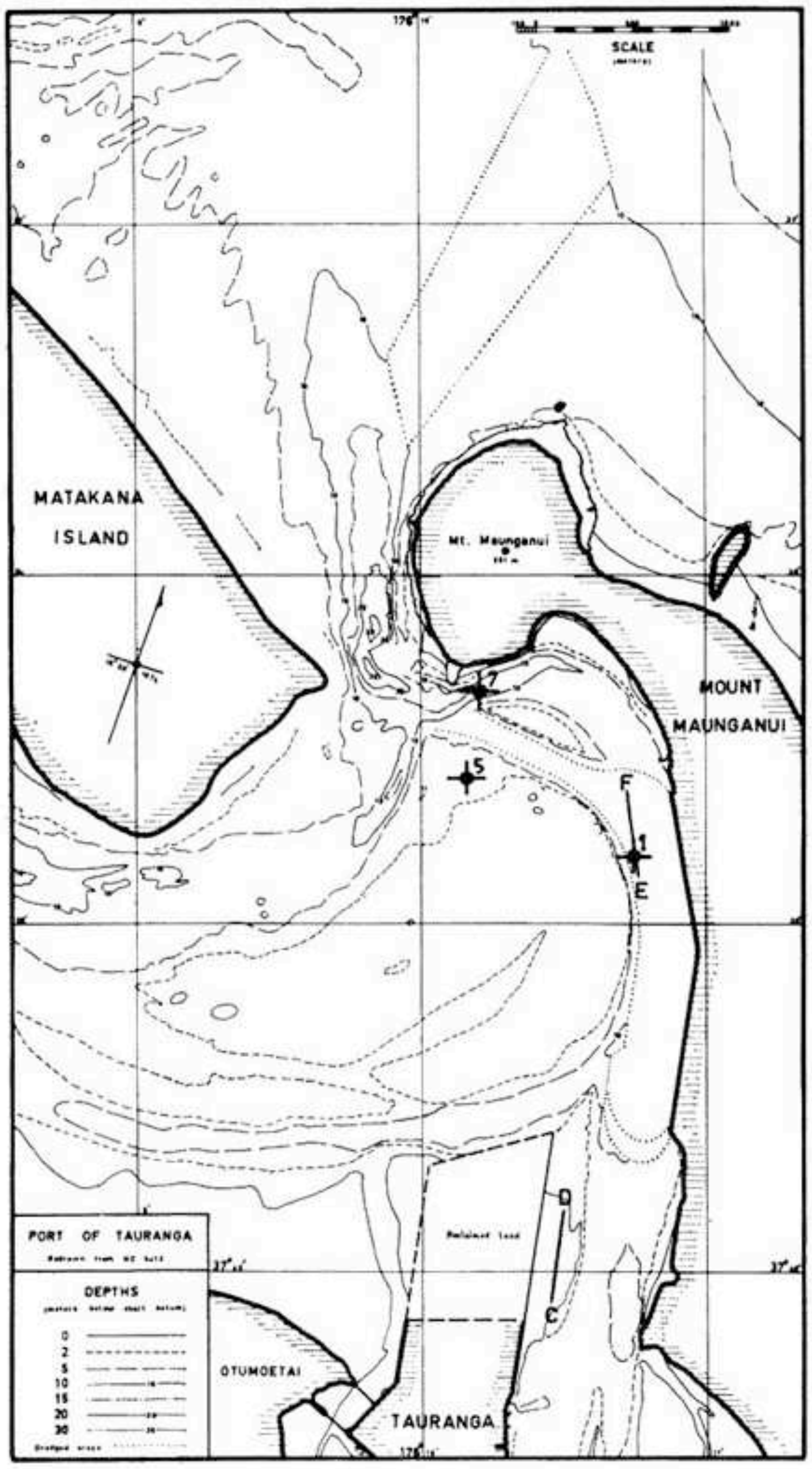

FIGURE 1. *Tauranga Harbour Entrance. Bathymetric map showing locations of stations referred to in the text and echo-sounding runs.*

particularly mean grain size and sorting, can be related to tidal current and/or wave regime. Coarse shelly lag sediments occurring near the Tauranga Harbour entrance reflect the relatively high energy of this environment. The occurrence of these coarse sediments made conventional grab sampling impractical since the shelly gravel frequently jammed the sampler jaws. This allowed washout of finer sediment leaving a non-representative sample. To overcome this problem a "groper" sampler was designed (Healy and Davies-Colley, 1974, refer to Fig. 2).

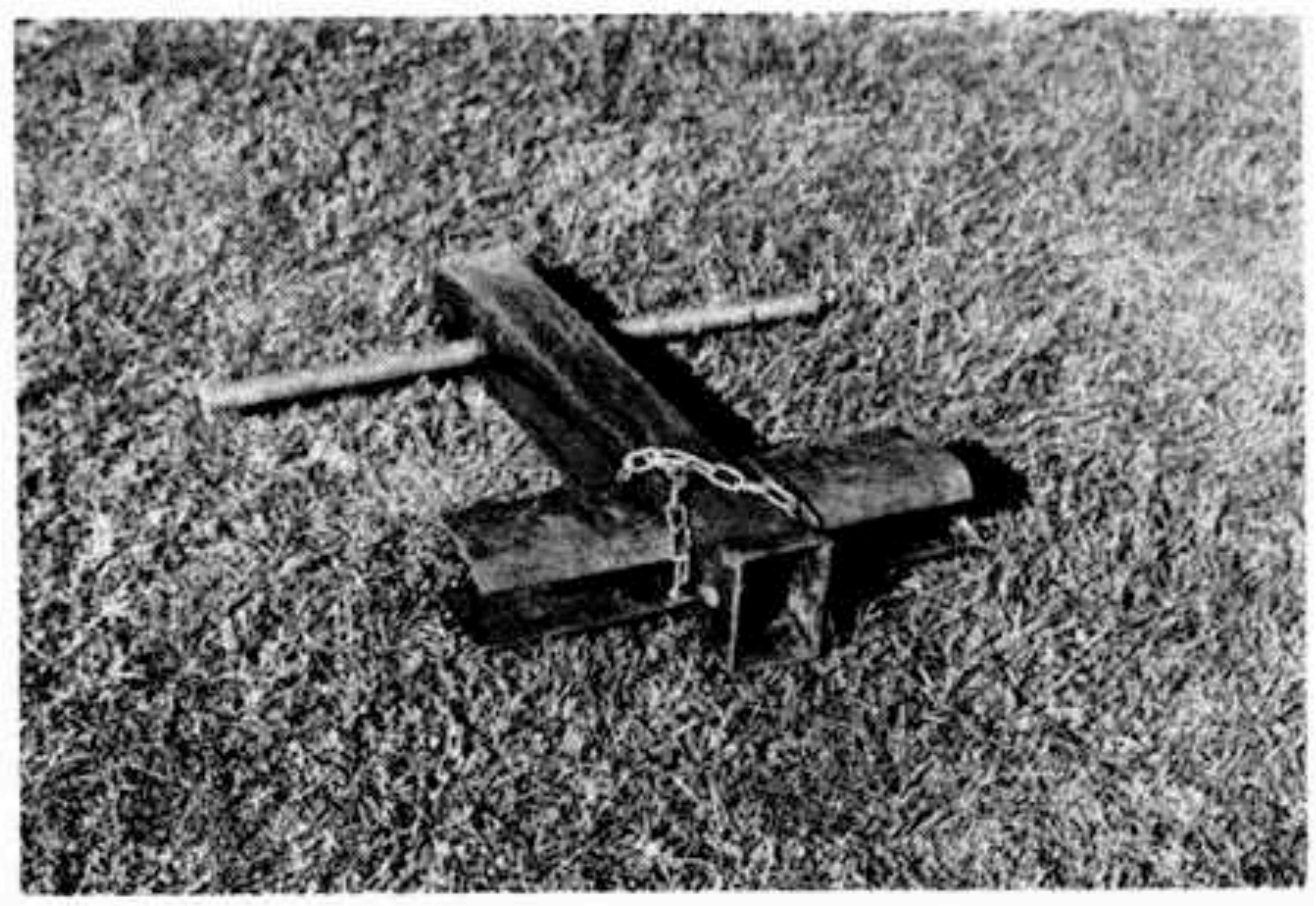

FIGURE 2. *The "Groper" dredge sampler.*

This sampler is essentially a dredge which takes a ten centimetre wide slice of sediment when dragged a few metres across the sea floor by a rope from the sampling boat. The device was observed in operation underwater by divers who found it to suffer minimal loss of fine material while successfully sampling the coarser grades up to about 5 cm in grain diameter. A sample sufficiently large for grain size analysis (up to about 3 kg of coarser sediment in the study area) can be obtained with this sampler.

TIDAL CURRENTS

Tidal currents have been monitored at a number of stations set up in the study area. Average speeds over a one minute interval were measured 100 cm above the sea bed (symbolised $\overline{U}_{100}$) using a small Watts current meter mounted on a tripod. Tidal currents have been monitored continuously for a whole ebb-flood semi-diurnal tidal cycle (12.5 hours of record). Using the results of such monitoring it is possible to predict whether sediment will move a net direction with either the peak ebb current or with the peak flood current. An order of magnitude net discharge of bedload sediments can be calculated from the tidal current records using sediment transport formulae. Fig. 3a shows a tidal current record for an "ebb" channel (Robinson, 1960) at Station 7 (Fig. 1) in which a net ebb-directed sediment transport occurs. Superimposed on the graph is the critical erosion velocity 1 m above the bed (U_{cr}) at which the sediment at Station 7 begins moving. Values of U_{cr} were taken from Allen's (1965) critical erosion velocity curve. U_{cr} is a function of the critical bed shear stress, $\tau_{cr} = u_* . \rho$ (where u_* is the shear velocity and ρ is the fluid density, Sternberg (1968, 1972)). Sediment movement occurs on that part of the tidal cycle when $\overline{U}_{100}$ exceeds U_{cr} at about 40 cm.s^{-1} at Station 7.

A tidal current record for a shoal area of the flood

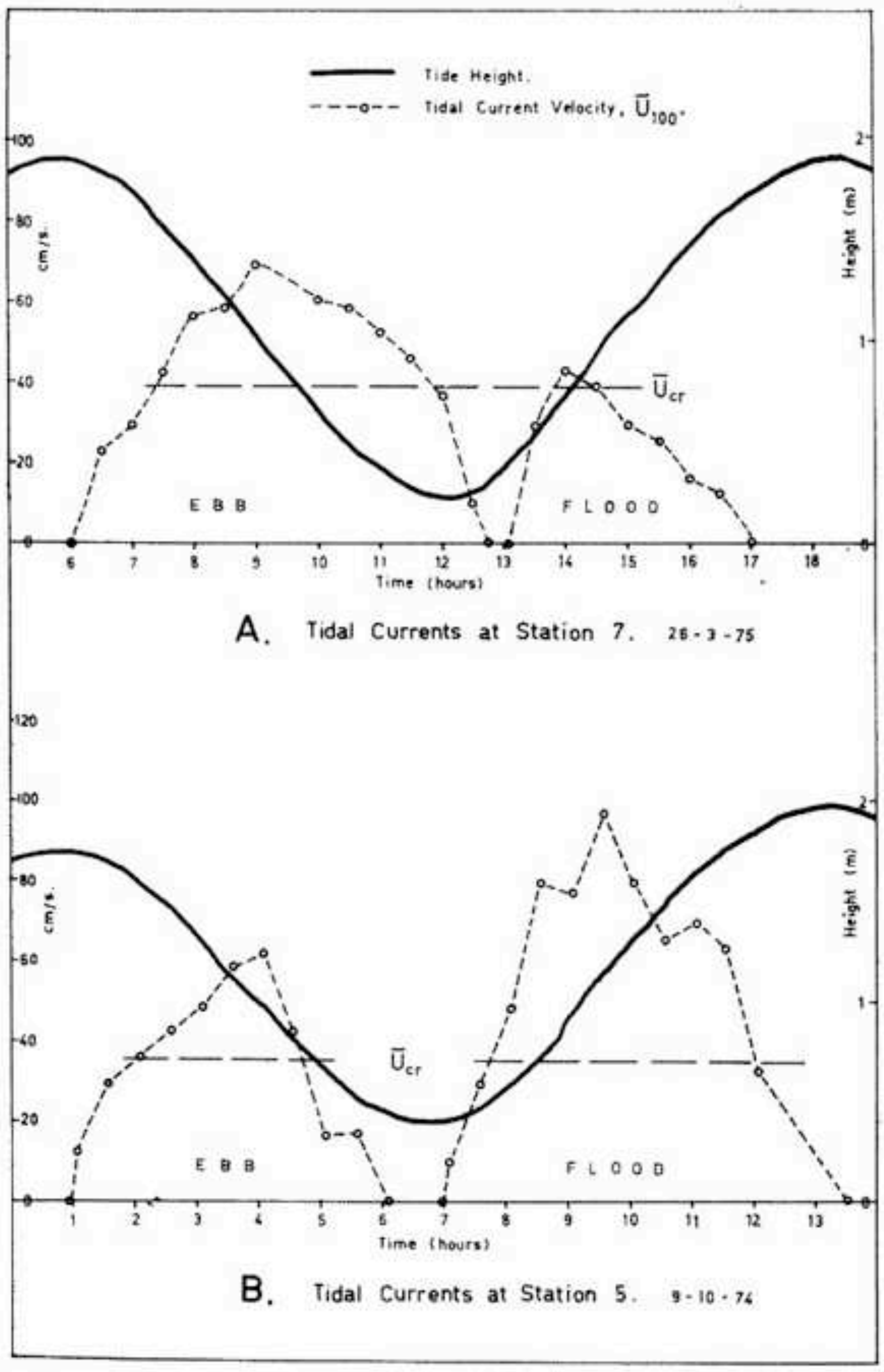

FIGURE 3. *Tidal current records.*

tidal delta is shown in Fig. 3b (Station 5). At this location net sediment drift is in the flood direction since the flood tidal current is more powerful than the ebb and exceeds U_{cr} at this station for a longer period of time over a tidal cycle.

DIRECT MEASUREMENTS OF SEDIMENT MOVEMENT

Rates of sediment movement were measured by various devices lowered to the sea bed or dug into the harbour floor by divers. All these sediment traps worked on the principle of trapping mobile sediment for a set period of time after which the trap was retrieved and the sediment content weighed.

A simple pit trap (Fig. 4a) was used in preliminary work. This trap was simply a lid flush with the sea bed with a slot aligned perpendicular to the direction of sediment movement. Bedload sediment fell into this slot and was trapped in the cylindrical container buried in the sea bed. The device was installed by divers at low water and recovered at high water yielding a flood tide record of sediment movement. The reverse procedure was used for an ebb record. This device was a fairly efficient trap of sediment, that is, the measured load was a high proportion of total sediment load. Unfortunately, it was very wasteful of diver underwater-time, requiring about 20 minutes for each installation.

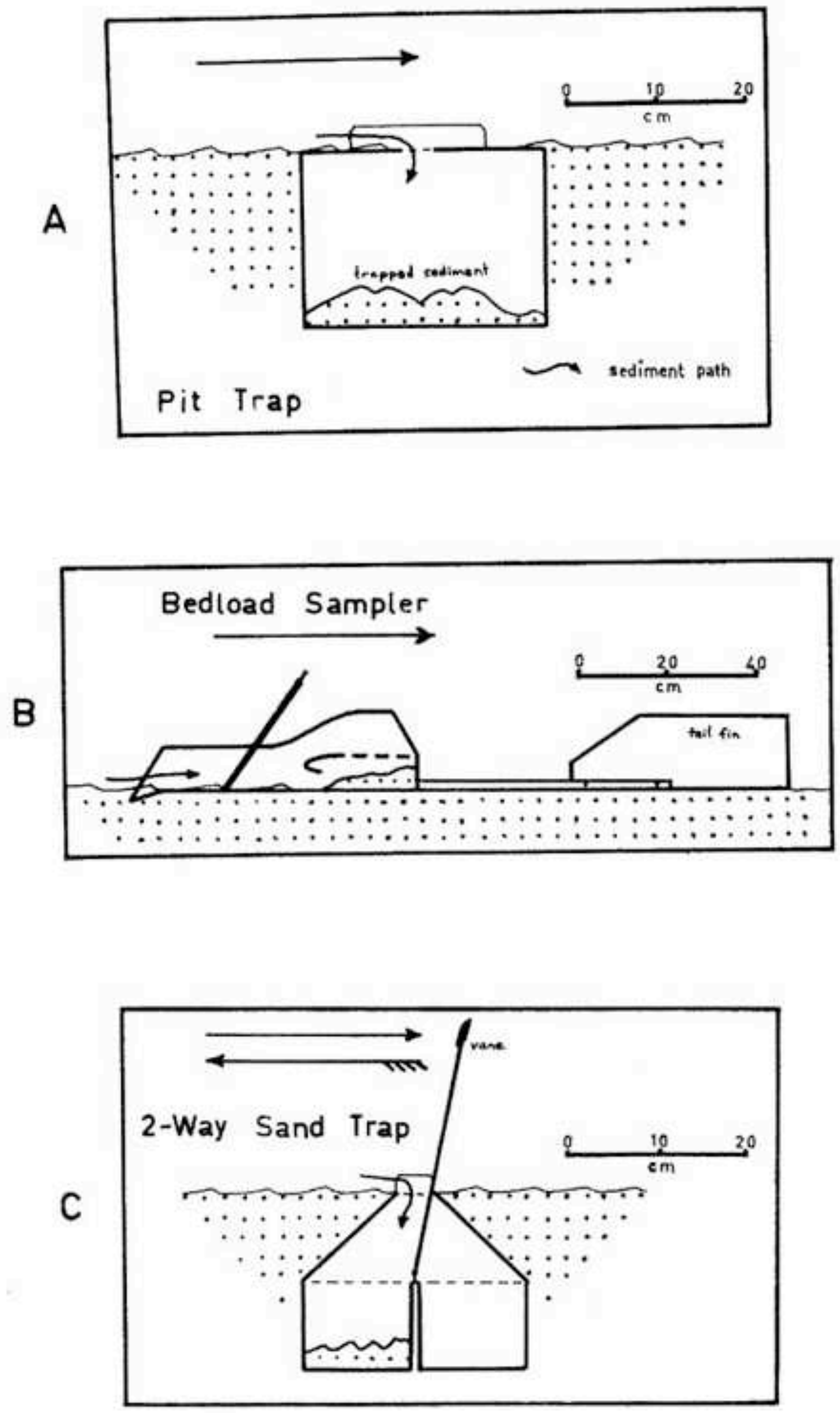

FIGURE 4. *Bedload sediment traps: (a) Pit trap. (b) Bedload sampler. (c) 2-way sand trap.*

To overcome the problem of excessive diver-time a remote bedload sampler was constructed based on a design described by Graf (1971) (refer to Fig. 4b). This device is lowered to the harbour floor and aligns itself with the sediment-entraining tidal currents by means of the tail fin. Sediment rides up the blade in the front of the device and is trapped by a baffle system inside while water can escape out the back. This bedload sampler seemed to work successfully in trapping sediment but was difficult to use in turbulent choppy water when wash-out of the trapped sample occurred. The two devices described so far provided a picture of net sediment movement directions at points in the study area. To gain a better understanding of relative rates of net sediment discharge a more complex sediment trap was designed (Fig. 4c). This trap consisted of two compartments, one to trap ebb bedload and the other to trap flood bedload sediment. Separating the two compartments was a moveable divider pivoted along the dividing wall and connected to a vane projecting up into the boundary layer tidal currents. This vane acted as a switch controlled by water motion so that the device switched over between compartments on reversal of the tidal currents. Like the pit trap this device was installed by divers at monitoring stations in the study area and left for two tidal cycles before recovery.

Using this flip-flop sampler an ebb discharge of 1.4 kilos per metre perpendicular to the trap slot was obtained at Station 7 (Fig. 1) on the 28-29th April, 1975, and only 0.2 kilos per metre on the adjacent flood tide. This verifies the inference on the basis of bottom current measurements that this station is in an ebb channel and provides an actual estimate of sediment transport rate. (Interested persons can obtain more detailed information about the devices briefly described above by contacting the author).

Fluorescent tracing of sediment movement has also been used in the Tauranga Harbour study. About 100 kg of fluorescent-dyed natural harbour sand was released at Station 5 and sediment samples were taken on a grid system covering the surrounding area at various time intervals after tracer release. This tracing experiment showed that the dominant dispersal of sediment from Station 5 was flood-directed in response to the more powerful flood tidal currents.

STUDY OF BEDFORMS

Allen (1968) has classified bedforms into two main physical scales: ripples and megaripples. Both ripples and magaripples have been observed to occur in Tauranga Harbour. Small scale current ripples have been observed to occur only on harbour bed sediments with a mean grain size less than about 0.7 mm. Flume experiments by Guy *et al*, (1966) using much better sorted sands than are found in Tauranga Harbour, have shown that this size is the limiting size for small-scale ripple development. It is interesting that the relatively poorly sorted harbour sediments seem to have the same size limitation for ripple formation.

Small-scale wave ripples have also been observed in shallower water near the harbour shorelines. These are distinct from current ripples in that they are symmetrical-trochoidal in profile rather than skewed-asymmetrical like current ripples.

In channel areas of strong tidal currents, divers have observed small-scale current ripples occurring superimposed on tidal megaripples at slack water. As the tidal current accelerates on the succeeding phase of the tide a critical value of fluid power may finally be reached at which the small-scale ripples are washed out and only larger bedforms persist. Fine-grained sandy sediment is thrown into suspension at this point and has been observed by divers to begin to move over the megaripples. This agrees with Allen's (1968) contention that suspension of sediment is involved in megaripple formation.

An attempt to measure the rate of movement of some megaripples has been made by the author. Divers set up an anchor plate with a submersible buoy to mark a reference point on the sea bed at Station 1 (Fig. 1). Several points on the crest of a megaripple some 30cm high and 15m long were marked with steel pins a measured distance from the anchor plate. The movement of the megaripple crest over a period of months could then be monitored. The experiment showed that at this point megaripples were almost stationary in the long term (little net sediment movement) but the crest position oscillated with ebb and flood tide phases.

The larger bedforms have also been studied by echo-sounding. Traces of echo-sounder profiles across megaripples are shown in Figure 5 for which two

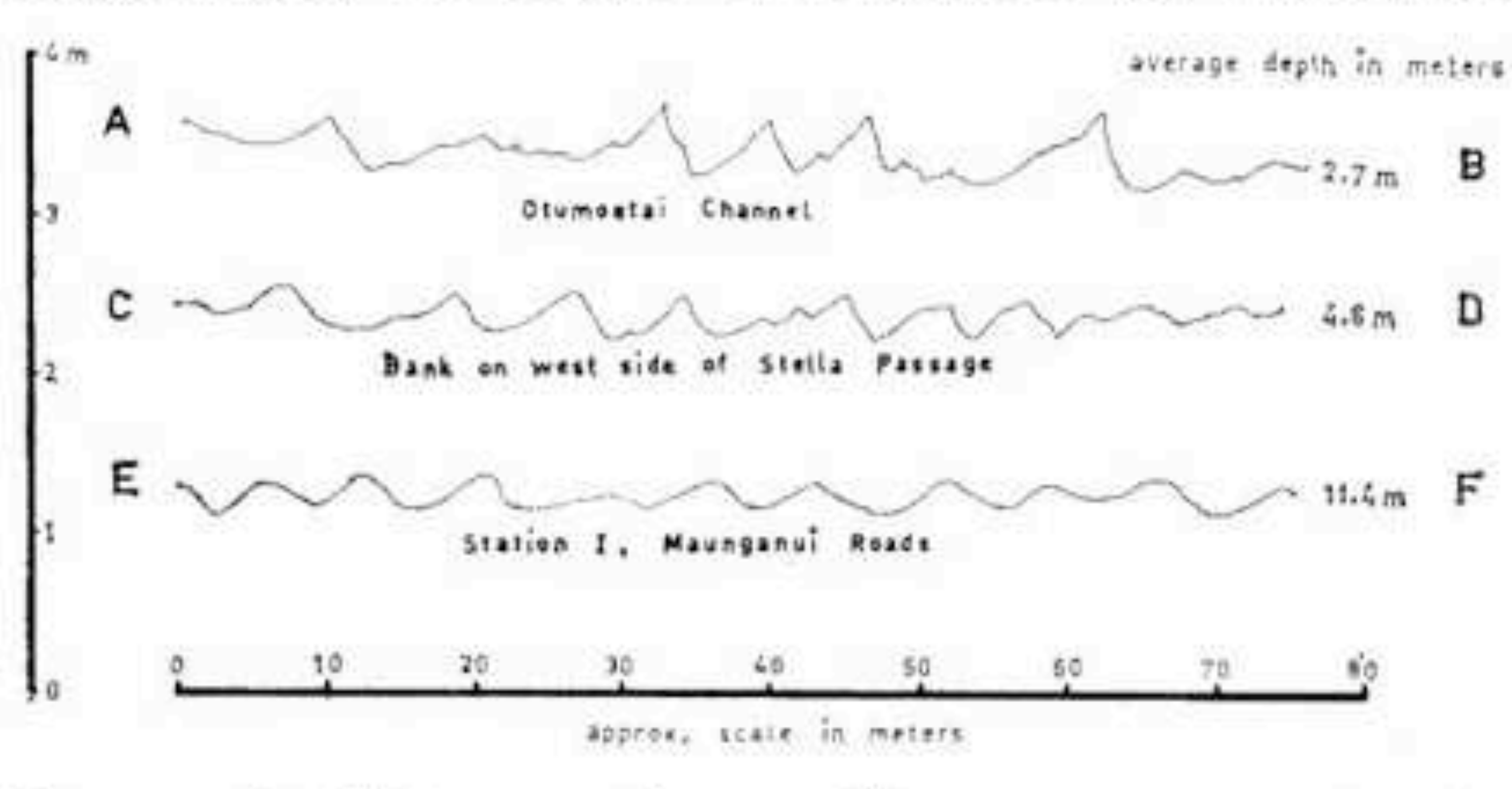

FIGURE 5. *Echo-sounder profiles across megaripples. (See Fig. 1 for the location of echo-sounder runs C-D and E-F. Run A-B is off the limits of the map.)*

of the sounding lines are shown in the map. Distortion of the true megaripple profile in the deep water trace (greater than 10m depth) is due to lack of resolution of the beamed signal from the sounder. The sounder used for these runs was a Kelvin-Hughes MS-36 with a conical-shaped beam of 14° divergence. A narrower-beamed instrument would be necessary for obtaining profiles of tidal bedforms in detailed studies where water depths are greater than about 5m.

CONCLUSIONS

Some of the field techniques and apparatus used in this study are somewhat unusual and this has prompted the writing of this paper. In particular, diving operations have been found to be an essential research tool, permitting direct observations and installation of monitoring devices on the sea bed. Monitoring of tidal currents in the boundary layer has provided a picture of tidal current control of sediment dynamics near a lagoonal inlet. Sediment sampling posed problems for conventional samplers which were largely overcome by using a new type of dredge sampler. Three devices were used to provide direct estimates of sediment movement. Probably the most successful of these was the flip-flop sampler which catches bedload sediment on both the flood and ebb phases of the tide. A study of tidal bedforms provided detailed knowledge about rates and directions of sediment movement and threw light on the processes of sediment erosion and transport.

It is hoped that the integration of these approaches to the problem of sediment dynamics of the Tauranga Harbour entrance will provide useful information for planning of further development of the Port of Tauranga.

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