
A MARINE SURVEY FOR THE SLEEPY

LAGOON MARINA

BUREAU OF PLANNING
GOVERNMENT OF GUAM
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by
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A MARINE SURVEY FOR THE SLEEPY LAGOON MARINA¹

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Introduction and Background

Mr. Albert A. Waller is submitting a proposal to the Department of Land Management (Government of Guam), the U. S. Department of Interior, and the U. S. Army Corps of Engineers to dredge, construct a causeway, and build a small boat marina on submerged land at the north end of Agana Bay. This submerged land is located seaward of Lot No. 2147-1-W within the municipality of Tamuning (Fig. 1). It is necessary for Mr. Waller to file an Environmental Impact Statement and obtain permission from the above governmental agencies. He contacted the authors of this report through the Director of the UOG Marine Laboratory. The results of our survey are contained herein.

This report does not constitute a complete Environmental Impact Statement. Instead, it is an environmental impact survey or assessment from which Mr. Waller may extract details for his final statement.

The report is based upon drawings furnished by Mr. Waller. Figures 1 and 2 are from these drawings. The field work for this survey was started on November 1, 1973, and was finished on December 10, 1973.

Project Description

The overall project is a resort-hotel-condominium-marina development. Proposed marine development includes the following:

1. Deepening the natural channel south of Alupat Island to a low tide

¹This work and the opinions contained herein are those of the authors and not necessarily those of the University of Guam, the UOG Marine Laboratory, or the Government of Guam. The project is considered a community service, and the work was conducted by the authors on their own time.

depth of 15 feet (Fig. 2). This channel will be 60 feet wide and 540 feet long.

2. Development of marina facilities between the above channel and the southeast side of Alupat Island (Fig. 1). This marina area will be approximately 300 feet by 600 feet and will accommodate slip mooring for some fifty boats.
3. Construction of a canted breakwater at the west end of the mooring area between Alupat Island and the channel to the sea (Fig. 1).
4. Construction of a low-rise, concrete, pile-supported bridge which meanders from the marina to the shore (Figs. 1 and 2).
5. Dredging of the reef-flat platform from the marina area to the shore to a depth of approximately 15 feet below MLLW. This region is approximately 500 feet wide at Alupat Island and tapers toward the shore, where it is 200 feet wide.
6. Dredging of a maneuvering area to the south 600 feet wide, 2,700 feet long, and approximately 15 feet below MLLT (Fig. 1). This dredged area lies 100 yards seaward of and parallel to the shoreline.
7. Coral rock dredged from the channel will be used to backfill the breakwater at the west end of the mooring area. Sand dredged from the mooring and maneuvering areas will be used to enhance the existing beach along the project site, the beach bordering the maneuvering area, and the sand bar at Alupat Island.
8. Construction of a boat-launching ramp at the project site.

Environmental Setting Without the Project

Supratidal Zone

This zone includes the supratidal shoreline along the Agana Bay project

site at Lot No. 2147-1-W, the 2,700-foot maneuvering zone, and Alupat Island. The beach along the project site and maneuvering area is generally known as Dungca's Beach. The shoreline at the north end of the Agana reef-flat platform consists of a limestone cliff approximately 70 feet high at the seaward edge. This cliffed headland dips downward to the north, where it forms an irregular limestone slope about 20 feet high. This slope is set somewhat back from the shoreline at the north end of the project by a strip of unconsolidated beach deposits, and it dips below the general level of these deposits at the south end of the project lot. Unconsolidated beach deposits border the remainder of the shoreline south of the project site.

At the present time the supratidal region along the project site and maneuvering area is occupied by a grass--weed--shrub community and a few scattered trees. Wiry, mat-forming grass--*Paspalum vaginatum*--forms a band along the beach in many places. This grass commonly extends seaward to the high-tide level and in some instances may even be covered with sea water.

Some natural vegetation covers the seaward edge of the cliff face at the northern end of Agana Bay.

Alupat Island is a rocky, limestone islet which rests on the outer part of the reef-flat platform. The highest part of the island is about 20 meters high and is mostly covered with trees and shrubs. The island is uninhabited and undeveloped at present. Cliffs and steep slopes border the shoreline except on the south side, where a sand bar approximately 55 meters long and 20 meters wide has developed. The beach morning glory--*Ipomoea pes-caprae*--occupies the inner 15 meters of the sand bar. Strand vegetation has developed along the shoreward side of the sand bar and consists mostly of trees such as: *Scaevola taccada*, *Messerschmidia argentea*, *Thespesia populnea*, *Hernandia*

nymphaeifolia, and *Hymenocallis littoralis* spider lilies. On the supratidal rocks the common trees and shrubs are *Triphasia trifolia*, *Terminalia littoralis*, *Mammea odorata*, and *Clerodendrum inerme*. Ferns are common, and scattered sedges are growing on the +6-foot "nip" ledges.

Hermit crabs--*Coenobita* sp.--are common in the strand vegetation, and the blue-tailed skink *Emoia cyanura* frequents the sunny rocks along the cliff edge. Several Polynesian rats--*Rattus exulans*--were observed moving about during the daylight hours on the higher parts of the island.

Regions of bare rock are very rough and irregular because of solution pitting. A prominent +6-foot fossil "nip" is cut into the rocky cliffs at some places. A few limestone blocks several meters in diameter appear to have eroded from the rocky cliffs and now rest on the reef-flat platform at several locations around the island.

The shoreline along Agana Bay reef flat is nearly all developed with residential housing and apartment units. A large, eight-story condominium is located on the low limestone cliff along the north end of the reef flat. The village of Tamuning borders the shoreline south of the project site and is extensively developed with commercial and residential structures.

Intertidal Zone

The intertidal shoreline along the Agana Bay project site consists of a narrow beach zone of sand and gravel. At the north end of the project site, approximately where the proposed reef-flat bridge is located (Fig. 2), the intertidal zone contains scattered boulders and coarse gravel mixed with beach sand.

The intertidal zone along the north end of Agana Bay consists of steep limestone slopes and cliffs. The limestone cliff is cavernous and at places

has a sea-level "nip" cut along the base.

The intertidal zone south of the project site and parallel to the maneuvering (Dungca's Beach) area consists of unconsolidated beach deposits except for a low, rocky outcrop about two meters in height and 20 meters long.

The entire beach and intertidal zones along the project site and maneuvering area have been disturbed by the laying of a sewerage trunk line, which is buried beneath the surface. At intervals of about 100 meters or so, manholes rise above the general level of the beach a meter or less.

At Alupat Island the intertidal zone consists of a prominent, cut "nip" along the rocky shores and of unconsolidated sand and gravel on the east side of the island where the sand bar has developed. A small boulder zone is located along the north side of the sand bar where it joins the island. The boulders in this region are dark colored because of the presence of boring blue-green (Cyanophyta) algae. The seaward side of the island receives more wave assault, and at places the floor of the cut "nip" is scoured by the action of waves, transported sand, and gravel.

Table 1 lists the organisms encountered in the intertidal zone. *Enteromorpha intestinales* is the most conspicuous organism along the intertidal zone of the project site and maneuvering area to the south. This bright green algae forms dense, filamentous mats on the beach. It is particularly abundant at the north end of the project site where a drainage ditch leads to the beach along a narrow access road (Fig. 1). At low tide the beach is covered with extensive mats of the algae as thick as 15 cm, and during the heat of midday, it gives off a distinct odor. The presence of this same algae has been a source of annoyance for hotels located along Tumon Bay. Some ghost crabs, *Ocypode* sp., were observed along the sandy beaches, as were many

burrowing crabs. Also a species of *Ocypode*, the burrowing crabs dig small holes about a centimeter in diameter. The density of occupied burrows of this crab is about 52/m². (See Fig. 1, transects K and L, for sources of crab data.) Amphipods are common along the sand beaches and are especially concentrated at places where beach drift and algal mats occur. With the exception of *Enteromorpha intestinales* and the *Ocypode* sp. burrowing crab, essentially the same floral and faunal communities are found on the intertidal parts of the sand bar at Alupat Island.

Limpets, chitons, nerites and littorine snails, and grapsid crabs are found in the sea-level "nips" and on other rocky surfaces along the north end of Agana Bay and Alupat Island. Conspicuous algae growing in intertidal "nips" and on other rocky surfaces are *Ralphsia* sp., *Champia* sp., *Ectocarpus* sp., and several species of thinly incrusting calcareous algae.

Reef-flat Platform

The reef-flat platform can be divided into two zones (Fig. 1)--inner reef flat and outer reef flat. The outer reef flat is slightly higher with respect to the inner reef flat and is consequently exposed during lower tides, whereas the inner reef flat retains some water. This inner band of water is commonly referred to as the "moat". At the northern end of the Agana Bay reef flat, the inner reef flat zone can be further subdivided into a wide, inner, sandy subzone and a narrower, mixed-coral subzone. The outer reef-flat platform is considerable narrower than the inner reef-flat platform and is interrupted by a shallow channel on the south side of Alupat Island. During low tide the channel is approximately 0.3-0.5 m in depth. This channel may have originally been a depressed region along the reef margin, but observations made where it cuts through the outer edge of the reef-flat platform indicate that it may

have been deepened by artificial means--dredging, blasting, and so forth. Natural channels usually contain well-rounded boulders on their floors, whereas many of the boulders on the floor of this channel are angular and irregular. Approximately 1,000 feet south of this channel, another shallow channel cuts across the reef margin and outer reef-flat zones. At low tide this channel is slightly more shallow than the channel south of Alupat Island. The distribution of the reef-flat zones and subzones are shown on Fig. 1.

The 2,700-foot maneuvering area lies entirely within the inner reef-flat sand subzone. The proposed marina and channel lie mostly within the inner reef-flat coral subzone. The dredged area between the island and the project site lies mostly within the inner reef-flat sand subzone.

In 1965, Mr. Waller started to construct a causeway from the north side of the project site to Alupat Island. This project was never completed because he lacked a permit to dredge in subtidal lands. At one time the top of the causeway was exposed above the mean high tide level. Subsequent storm waves have eroded the causeway to the extent that it is now exposed only during lower low tides. Material to construct the causeway was dredged from each side, leaving two channels which are considerably deeper than the general reef platform level.

Depths of the various reef-flat zones in the project are shown in Figs. 3 and 4. At extreme low tides (-0.9) much of the inner reef-flat sand subzone now would be exposed, except for minor depressions, holes, and the two artificial channels which lie parallel to the eroded causeway. From the above profiles, it is apparent that the inner reef-flat sand subzone increases in depth seaward toward the coral subzone, which is the deepest part of the reef-flat platform.

The coral subzone grades into the outer reef-flat zone, which is partly

exposed during mean low tide and mostly exposed during extreme low tides (-0.9). The seaward part of the outer reef flat is flat and pavement-like with very little relief except for occasional shallow depressions and holes. On the inner part of the outer reef flat, boulder zones have developed from material which has been eroded from the reef margin and reef front by storm and typhoon waves. These boulder zones are particularly well developed on both sides of the shallow channel north of Alupat Island. These two boulder accumulations are about 0.3 m higher than the general outer reef-flat platform.

Between Alupat Island and the north shore of Agana Bay, the inner reef-flat coral subzone is wider than that to the south of the island (Fig. 1). A slight depression on the outer reef-flat zone is found at the extreme northwest corner of the reef-flat platform near a narrow fringing platform, commonly known as "Rick's Reef."

The inner reef-flat sand subzone substrate consists mostly of sand, gravel, and mollusc shells. Very few boulders or large coral fragments are found in this region. The relief is relatively flat except for a few holes up to a meter or more in diameter which are located along the shore near Transect C (Fig. 1). These holes are caused by the erosion of sand by submarine springs. A conspicuous "boil" of water occurs at ten or twelve locations about 50-75 feet from shore. These springs are aligned in a more or less straight pattern and could be related to water escaping from the island's fresh-water lens system via a minor fault or joint zone. Another possibility is the escape of sewage effluent through ruptured areas in the sewer trunk line which borders the beach. No detectable sewer odor, though, was noticed, and marine fishes were observed feeding in the "boil." The above condition was reported to the Guam Environmental Protection Agency, which reported that

the sample water showed "no evidence of unusual fecal contamination" (Inter-Agency Memorandum, 9 January 1974, T. A. Determan).

A plastic lime-mud zone forms a band approximately 20-40 meters wide along the shore of the inner reef-flat sand subzone from the project site southward to the end of the proposed maneuvering area.

The substrate in the inner reef-flat coral zone consists of sand, gravel, scattered boulders, coral-algal-mollusc rubble, and some living microatolls of coral. In a seaward direction the amount of sand decreases, and the coral-algal-mollusc rubble increases. The extreme seaward edge of the inner reef-flat coral subzone consists of dead *Acropora* thickets, boulders, coral-algal-mollusc rubble, and a thin veneer of sand over consolidated reef rock. These dead *Acropora* thickets are in position of growth and were apparently killed during the low tides of October, 1972.

The outer reef-flat zone consists, for the most part, of a consolidated reef-rock platform except for the inner part, which contains accumulations of boulder rubble. The outer part of this zone is flat and pavement-like and generally lacks any unconsolidated material except for a thin veneer in shallow holes and depressions.

The substrate in the channel immediately north of Alupat Island consists of bare reef rock and scattered boulder rubble.

Table 1 lists organisms found in the various reef-flat platform zones, and Fig. 1 shows the locations of the biological transects. The dominant community found in the inner reef-flat sand subzone is an algal-polychaet-anemone-mollusc population. Near the intertidal zone *Enteromorpha intestinales* is the most abundant algae. Large floating masses up to 1 m or more in diameter are common in this region. The *Enteromorpha* community diminishes in a seaward direction and is nearly absent where the inner reef-flat sand subzone grades into

the coral subzone. Corals are conspicuously absent from the inner reef-flat sand subzone except for an occasional fragment and a few colonies in the north channel along the causeway from the project site to Alupat Island. These corals in this artificial channel appear to have grown there because of the deeper water; however, many of them are now dead. It is our belief that they were killed during a series of exceptionally low tides in October, 1972.

Other than scattered clumps of benthic algae, the only conspicuous organisms are polychaet annelids and randomly distributed holothurians. Large aggregations of *Cerithium* sp. form extensive bands in the mid to outer part of the sand subzone. The reason for the aggregation behavior is unknown. In other parts of the sand subzone, populations are widely scattered or absent. In-sand communities consist of numerous tube-forming worms, burrowing anemone-like forms, sipunculans, and various species of bivalve molluscs. The most abundant bivalve is *Quidnopagus palatum*, which forms dense aggregations, particularly along the inner third of the sand subzone. Other sand-associated molluscs and crustaceans are found in the same area, as are occasional por-tunid and stomatopod burrows. *Calappa calappa* is also seen scurrying across the sand.

There is a conspicuous increase in diversity and abundance of algae, corals, and other invertebrates in the inner reef-flat coral subzone. Dominant corals are *Pocillopora damicornis*, *Porites lutea*, and *Acropora aspera*. Even though corals are present, the substrate coverage is still less than two per cent except for Transect 1 near Alupat Island (Fig. 1 and Table 2). *Caulerpa racemosa* and *C. taxifolia* form extensive mats several meters or more in diameter. *Gracillaria salicornis* forms numerous, hollow, dome-shaped growths which in some places are overgrowing and killing living corals. Other clump-forming algae observed are *Dictyota* sp., *Acanthophora spicifera*,

and *Halimeda opuntia*. Conspicuous patches of *H. macroloba* and *Avrainvillea obscura* are found wherever accumulations of sandy substrates are present. Nodules of various species of calcareous red algae are common to abundant throughout the subzone. Coral data from Transects E, F, G, H, I, and J (see Fig. 1) are summarized in Table 2.

Holothurians such as *Holothuria atra*, *H. leucospilata*, *H. edulis*, *Actinopyga mauritiana*, and *A. miliaris* are very abundant. Large *Linckia laevigata* are common throughout and are particularly abundant in the Alupat Island Channel. Sea urchins are found on rocky boulder substrates; the density of these and other echinoderms is listed in Table 3.

In general, greater coral coverage (Table 2) was found in this zone to the north of Alupat Island. Incrusting masses of *Palythoa* are common along the channel. Several large microatolls are located in the outer part of this subzone and are associated with numerous invertebrates, algae, and fishes.

The outer reef flat is periodically exposed during low tides, and consequently, corals are conspicuously absent except in depressed areas or in shallow holes. A low algal turf covers the outer part of the zone. Among the boulders on the south side of the channel are numerous grapsid, xanthid, portunid, and porcellanid crab species. At least four species of didemnid ascidians are to be found on the undersides of loose boulders. Numerous rough-water-adapted gastropods occur. (See Table 1 for complete list of forms.)

Reef Margin and Reef Front

The reef margin (surf zone) and the reef front form the seaward edge of the reef-flat platform. These two zones are poorly developed at the existing channel north of Alupat Island. The reef margin and reef front lack the

characteristic surge channel and buttress and algal ridge development which are commonly found in these zones at many other locations around Guam. In the vicinity of the channel, this region forms a low-angle, bare, rocky slope (the grade is generally less than 5 per cent) to the submarine terrace located about 100 m from the outer reef-flat platform (seaward end of Transect H, Fig. 1). The depth where this region grades into the submarine terrace is 8-10 m. Reef development is conspicuously lacking, and the surface relief is generally less than 1 m. At the extreme seaward edge of this region, reef development is somewhat greater, and the surface topography increases to 2 or more meters. The floor of the existing channel contains abundant boulders, coarse sand, and gravel.

The organisms found in this region are tabulated in Table 1. The inner part of the zone is densely covered with extensive mats of *Caulerpa racemosa*.

The percentage of living coral covering the substrate in the vicinity of the proposed channel is about 0.5 (Table 2, Transect H). Most of the colonies are small and scattered, and reef development in the form of coral-algal mounds, knobs, and bosses is conspicuously absent. There is a distinct increase in the percentage of substrate covered by living corals and reef development at the seaward end of Transect H, where the reef front grades into the submarine terrace zone. The most conspicuous corals here are large flabellate colonies of *Heliopora coerulea* and columnar growths of *Porites (S.) iwayamaensis*.

Current Patterns

The current patterns and conclusions given in this report are based upon relatively few samples from two 24-hour periods. The reef-flat platform current study was conducted over a 24-hour period (November 23-24), and the data is presented in Fig. 5 and Table 4. The offshore current study was conducted

on December 9-10 at the seaward edge of the reef-front zone where the proposed boat channel cuts through the reef margin (Fig. 6). Offshore current patterns and a summary of the data are presented in Fig. 6 and Table 5, respectively.

Reef-flat platform currents were determined by injecting dye into the water mass and measuring the rate and direction of movement. Current patterns were determined offshore by measuring the rate and direction of movement of current drouges released from the seaward end of the proposed boat channel (Fig. 6).

REEF-FLAT PLATFORM CURRENTS-- The current patterns generated on the reef-flat platform are based upon the stand of the tide, reef-flat topography, mass transport of water over the reef margin and outer reef-flat zones into the depressed moat of the inner reef-flat zone, wind direction, swell height and direction, and sea height and direction. During this study the wind direction ranged from 025° to 050°, and the speed, from 5 to 20 knots. Swell direction was from the northwest, producing surf at the reef margin zone 0.5 to 1.5 meters high. The sea waves were of short period, 0.3 to 1.0 meters high, and were from the same direction as the wind.

The majority of the current studies were conducted along Transect A, which extends from the project site through the boat mooring area to the reef margin at the proposed boat channel south of Alupat Island. Other stations were located on Transects B, C, and D to the south in the maneuvering area, along the outer reef-flat zone and shoreline, and on the inner reef-flat zone between Alupat Island and the north end of Agana Bay.

In general, the currents have a northerly component on the wide, inner reef-flat zone along Transects C and D during times when there is considerable mass transport of water over the reef margin. As this northward-moving current

approaches Transects B and A, it turns westward and then flows seaward via the depressed platform and channel located on the south side of Alupat Island into the Philippine Sea. During lower low tides, when mass transport over the reef margin ceases or is greatly reduced, there is still a reduced northern current component along Transects D and C, and it swings westward at Transects B and A. Current movement during this time is caused by the flow of the water, trapped in the inner reef-flat moat, escaping seaward through the depressed reef margin and channel south of Alupat Island as the tide falls.

Current direction was predominantly seaward (westward) along Transects A and B, as noted above, except during the early part of the flood-tide period from lower low water to higher high water (0130-0400, November 24), when the current had an easterly to southeasterly component on the inner reef-flat zone (Fig. 5). During this early part of the flood tide, the current in the boat channel was reversed from the predominant western seaward flow and flowed eastward into the inner reef-flat moat zone.

This eastward-flowing current in the boat channel began to slow down as the tide continued to rise and finally reversed as the mass transport of water over the reef margin and outer reef flat zones piled water into the inner reef-flat moat.

Current patterns to the north of Alupat Island are more complicated because of the remains of a causeway in the vicinity of the proposed bridge which extends from the shore to Alupat Island. During lower tides this causeway is exposed and prevents the exchange of water from the inner reef-flat zone north and south of Alupat Island. During higher tides, there is some exchange of water across the causeway, particularly at the west end near the island and near the shore where it is somewhat lower. During high tide with wave transport over the reef margin, the currents on the inner reef-flat zone north of

Alupat Island tend to flow eastward and then sweep southward around the island and back to the sea through the boat channel on the north. During low tides with little wave transport over the reef margin, there is a weak current to the west on this part of the reef flat. Near the project site the currents were generally weak and variable.

OFFSHORE CURRENTS-- The offshore current patterns shown on Fig. 6 are based upon a 24-hour study conducted on December 9-10, 1973. A permanent station was established 100 meters seaward of the proposed boat channel mouth on the north side of Alupat Island. A 1-meter-deep drift drouge was released from this station every two hours. After drifting for 46 meters, its bearing and time of drift were recorded, and the drift vector was then plotted (Fig. 6). Table 5 shows a summary of the current data taken during the 24-hour study. During the study, the transport of water over the reef margin and outer reef-flat zones into the inner reef-flat moat zone was quite high because of the presence of long-period swells, up to 2 meters in height, from the northwest. This condition caused a rather constant seaward-flowing current in the proposed boat channel. During the higher high-water flood tide, this seaward-flowing current was deflected to the northwest, and during the lower low-water ebb tide, it was deflected to the southwest (Fig. 6).

The current speed was relatively uniform during the study period except from 0600 to 0800 on December 10. During this time, the northwest swell increased in height, causing an increase in the amount of wave transport over the reef margin and a corresponding increase in the seaward flow of water from the inner reef-flat moat via the channel north of Alupat Island.

Area Use

The north end of Agana Bay appears to have a great deal of useage, and

during the field work of this study, the following activities were observed. Considerable fishing was carried out by individuals with either spears or poles. "Family" groups of as many as twenty men, women, and children used surround nets. Smaller groups of men carried out water-beating and coconut-line, drag-net methods to chase fish into the surround nets. Throw-netting was also observed on numerous occasions.

Clams were being dug in the waters on the north side of the Alupat Island sand bar. Shell collectors were observed gleaning the outer reef flat and the coral subzone.

Picnickers, representing diverse cultural backgrounds, were observed both along the shoreline and at the island, and large and small groups of children were seen playing.

On several occasions, catamarans were sailed from the Condominium shore into the lagoon or through the proposed channel to outside the reef. This channel appears to be the most used along the north end of Agana Bay. Other residents of the Condominium were seen walking along the shore and swimming near the island.

Environmental Impact of the Proposed Project

The potential modification of the marine environment will include the following:

1. Dredging in the proposed boat channel, marina area (region from the project site to the mooring area at Alupat Island), and maneuvering area will physically remove the present marine substrates and communities in these regions. The proposed dredging plan is to deepen these locations to approximately -15 feet below datum (MLLW). At present, the average (MLLW) depth of water over the

proposed reef-flat platform dredging locations is less than 1 meter (Figs. 3 and 4). Approximately 1,000,000 cubic yards of marine substrates will be removed if the dredging is completed to the proposed depth.

2. Dredge plume generated by the dredging operations may be carried by currents to other locations and cause damage to the marine environments there by siltation.
3. The construction of the proposed bridge (Fig. 2) between the project site and Alupat Island will:
 - a. block the movement of small craft from one side of the bridge to the other (except those low enough to pass under the proposed structure) at the north end of Agana Bay reef flat;
 - b. shade approximately 31,200 square feet of marine environment; and
 - c. cover, by pilings and pile footings, physically part of the benthic community on the reef-flat platform.
4. The construction of the proposed canted breakwater at the west end of the mooring area between Alupat Island and the boat channel will physically cover part of the benthic community on the reef-flat platform.
5. The construction of the proposed marina facilities at Alupat Island--such as piers, docks, and pilings--will physically cover marine benthic communities. Piers supported on floating structures will also shade marine benthic communities.
6. The construction of a boat-launching ramp will physically cover benthic and intertidal communities.

7. Dredge material used to backfill the breakwater will cover benthic marine communities, and sand used to enhance the beach along the project site, maneuvering area, and sand bar at Alupat Island will cover the existing intertidal and supratidal substrates there.

Discussion and Recommendations

of the Impact on the Environment by the Proposed Project

Proposed dredging activities will remove the present shallow reef-flat environment and substitute for it a deeper lagoon-like environment. The in-sand mollusc-worm-sipunculan community and benthic algal-coral-echinoderm communities of the inner reef-flat sand and inner reef-flat coral subzones will be removed by dredging. It is not known whether the same communities will recolonize the new deeper-water habitats. If the present communities do not recolonize the new, deeper habitats, these areas will almost certainly be colonized by a new community of organisms adapted to deeper water. The deeper water habitats will probably enhance coral development and diversity and also increase the biomass and diversity of the fish community.

Removal of the causeway which was partially completed in 1965 will improve the circulation pattern on the inner reef-flat platform, particularly at low tide, when it acts as a complete barrier to water movement.

The dredge plume presents a possible source of damage to adjacent communities if prolonged exposure and suspended silt accumulates. The current patterns on the north end of the Agana Bay reef flat will probably carry most of the generated dredge plume seaward through the depressed reef flat and channel north of Alupat Island. Dredging operations should be carried out when the above current conditions exist and should be suspended if the plume is carried to the south across the reef-flat platform or to the northwest

across the section of reef-flat platform located between the north side of Alupat Island and the north end of Agana Bay. Dredging operations should be carried out in the proposed boat channel and regions adjacent to it only when a seaward-flowing current is present.

Although the pilings and pile footings of the proposed bridge from Alupat Island to the project site will cover some benthic communities, it should also be pointed out that the pilings and footings themselves are adding as much or possibly more benthic surface for colonization by marine organisms. The shading effect of the bridge structures along with the new habitats the pilings and pile footings will probably create an environment which will attract fishes. Coral settlement will undoubtedly take place on the hard substrates of the submerged bridge structures. It is not expected that the submerged structures of the bridge will impede the flow of reef-platform current patterns to any great extent. The greatest objection to the construction of the pile-supported bridge will be in its obstruction of small-boat traffic. The bridge will probably attract a considerable number of pole fishermen, and net fishermen will undoubtedly use the pilings to attach nets.

If the boat mooring area is located at its proposed location, the breakwater will be required, as translatory waves generated on the reef margin swing by the south side of Alupat Island. There will probably be some changes in current and sediment transport patterns caused by the presence of the breakwater, but the exact nature of these changes are unknown.

The amount of dredged material appears to be in excess of the amount needed to backfill the breakwater and enhance the sand bar at Alupat Island and the beaches along the project site and maneuvering areas.

TABLE 1. Distribution of Marine Organisms. Data for this table was collected from transects shown on Fig. 1.

	Intertidal	Sand Subzone	Coral Subzone	Outer Reef Flat	Reef Margin	Reef Front
ALGAE						
<i>Acanthophora spicifera</i>			x			
<i>Actinotrichia fragilis</i>			x	x		
<i>Amphiroa fragilissima</i>			x	x	x	x
<i>Avrainvillea obscura</i>		x				
<i>Boodlea composita</i>		x	x			
<i>Bryopsis pennata</i>				x	x	x
<i>Caulerpa racemosa</i>			x	x	x	x
<i>C. sertularioides</i>			x	x		
<i>C. taxifolia</i>			x			
? <i>Champsia</i> sp.			x			
<i>Chlorodesmus fasiqata</i>					x	x
<i>Desmia horemanni</i>						x
<i>Dictyota bartayresii</i>		x	x			
<i>Enteromorpha intestinales</i>	x	x	x			
<i>Entophysalis</i> sp.	x					
<i>Galaxaura</i> sp. 1			x	x	x	x
<i>Galaxaura</i> sp. 2			x	x		
<i>Gelidiella acerosa</i>				x		
<i>Gracilaria salicornia</i>			x			
<i>Halimeda macroloba</i>		x	x			
<i>H. opuntia</i>		x	x	x	x	
<i>Hypnea</i> sp.			x			
<i>Jania capillacea</i>			x	x	x	x
<i>J. decussato-dichotoma</i>			x	x	x	
<i>Lobophora variegata</i>			x			
<i>Microleus lyngbyaceus</i>		x	x	x		
<i>Neogoniolithon frutescens</i>			x	x		
<i>Padina minor</i>			x			
<i>P. tenuis</i>			x			
<i>Polysiphonia</i> sp.			x			
<i>Porolithon onkodes</i>				x	x	
<i>P. gardineri</i>			x	x	x	
<i>Ralfsia pangoensis</i>	x			x		
<i>Sargassum cristaefolium</i>		x	x			
<i>S. polycystum</i>			x			
<i>Schizothrix calicola</i>				x		
<i>S. mexicana</i>			x			

Table 1, continued.

	<u>I</u>	<u>S</u>	<u>C</u>	<u>ORF</u>	<u>RM</u>	<u>RF</u>
ALGAE, continued						
<i>Sphacelaria tribuloides</i>				x		
<i>Spyridia velasquezii</i>		x				
<i>Turbinaria ornata</i>			x	x	x	x
<i>Valonia fastigiata</i>			x			
ANGIOSPERMS (Marine)						
<i>Enhalus acoroides</i>		x				
<i>Halophila minor</i>		x				
PROTOZOA						
<i>Calcarina spengleri</i>			x	x		
<i>Homotrema rubrum</i>			x		x	x
<i>Marginopora vertebralis</i>			x	x		x
PORIFERA						
<i>Cinachyra australiensis</i>		x	x	x	x	
"Sponge" spp.		x	x	x	x	x
CNIDARIA						
<i>Acanthastrea echinata</i>						x
<i>Acropora aspera</i>		x	x			
<i>A. convexa</i>				x	x	
<i>A. nana</i>				x	x	
<i>A. nasuta</i>				x	x	x
<i>A. palmerae</i>					x	
<i>A. surculosa</i>				x	x	
<i>Astreopora myriophthalma</i>						x
<i>Favia pallida</i>					x	x
<i>Favites complanata</i>					x	x
<i>Goniastrea retiformis</i>			x	x	x	x
<i>Heliopora coerulea</i>			x		x	x
<i>Leptastrea purpurea</i>			x		x	x
<i>L. transversa</i>					x	x
<i>Leptoria gracilis</i>					x	x
<i>Montipora elschneri</i>					x	x
<i>M. lobulata</i>					x	
<i>M. tuberculata</i>						x
<i>M. verrilli</i>					x	x
<i>Pavona clavus</i>						x
<i>P. decussata</i>			x			
<i>P. frondifera</i>			x			
<i>P. (P.) obtusata</i>			x			
<i>P. varians</i>					x	x
<i>Platygyra rustica</i>						x
<i>P. sinensis</i>						x
<i>Pocillopora brevicornis</i>					x	
<i>P. damicornis</i>		x				
<i>P. setchelli</i>					x	x

Table 1, continued.

	I	S	C	ORF	RM	RF
CNIDARIA, continued						
<i>Porites australiensis</i>						x
<i>P. cocosensis</i>			x			
<i>P. compressa</i>		x	x	x		
<i>P. lobata</i>					x	x
<i>P. lutea</i>			x	x	x	x
<i>P. (S.) iwayamaensis</i>						x
<i>Porites</i> sp.					x	x
<i>Psammacora contigua</i>			x	x	x	
<i>P. nierstraszi</i>			x			
<i>Stylarea punctata</i>		x	x			
<i>Stylocoeniellia armata</i>			x	x	x	x
<i>Stylophora mordax</i>					x	x
MOLLUSCA						
<i>Arca</i> sp.			x	x		
<i>Bursa</i> sp.			x	x		
<i>Cerithium</i> sp. 1		x	x			
<i>Cerithium</i> sp. 2		x	x			
<i>Conus pulicarius</i>		x	x			
"Coralliphilid" sp.			x			
<i>Ctene</i> sp.		x	x			
<i>Cymatium nicobaricum</i>			x			
<i>Cymatium</i> sp.			x			
<i>Cypraea moneta</i>		x	x	x	x	
<i>Dolibrifera dolibrifera</i>			x			
<i>Drupa</i> sp.			x			
<i>Gibberillus gibberillus</i>		x	x			
<i>Littorina</i> sp.	x					
<i>Mitra</i> sp. 1		x	x			
<i>Mitra</i> sp. 2		x	x			
<i>Mytilus septifer</i>				x		
<i>Natica</i> sp.		x	x	x		
<i>Nerita bensoni</i>			x			
<i>N. plicata</i>	x					
<i>Otopleura</i> sp.			x			
<i>Pinctada margaritifera</i>		x	x			
<i>Pinna muricata</i>		x	x			
<i>Polia undosa</i>		x	x			
<i>Pupa pupa</i>			x			
"Pyramedellid" sp.			x			
<i>Quidnophagus palatum</i>		x	x			
<i>Terebra maculata</i>		x	x			
<i>Tellina</i> sp.		x	x			
<i>Tridacna maxima</i>				x	x	x
<i>Trochus niloticus</i>				x		
<i>Vasum turbinellum</i>			x			
"Vermetid" sp.			x	x	x	x
<i>Volvetella</i> sp.			x			

Table 1, continued.

	<u>I</u>	<u>S</u>	<u>C</u>	<u>ORF</u>	<u>RM</u>	<u>RF</u>
ANNELIDA						
<i>Eurythoe</i> sp.			x	x		
<i>Sabellastarte</i> sp.			x	x		
<i>Spirorbis</i> sp.			x	x	x	
Unidentifiable spp.		x	x	x		
INSECTA						
<i>Halobates</i> sp.	x					
CRUSTACEA						
"Amphipod" sp.	x					
"Balanid" sp.				x		
<i>Calappa calappa</i>		x	x			
<i>Dardanus</i> sp.				x		
<i>Enoplometopus</i> sp.			x			
<i>Grapsus grapsus</i>	x					
"Grapsid" spp.				x		
"Ocypodid" sp.	x					
<i>Percnon</i> sp.				x		
"Porcellanid" sp.				x		
"Portunid" sp.		x	x	x		
"Stomatopod" sp. 1		x		x		
"Stomatopod" sp. 2		x				
"Stomatopod" sp. 3			x			
ECHINODERMATA						
<i>Acanthaster planci</i>					x	x
<i>Actinopya mauritiana</i>			x	x	x	
<i>A. miliaris</i>			x	x	x	
<i>Bohadsia argus</i>			x	x	x	
<i>Diadema savignii</i>			x	x		
<i>D. setosum</i>			x	x		
<i>Echinometra mathaei</i>			x	x		
<i>Holothuria atra</i>		x	x			
<i>H. edulus</i>		x				
<i>H. leucospilota</i>		x	x			
<i>Holothuria</i> sp.		x	x			
<i>Linckia laevigata</i>			x	x		
<i>Polyplectana kefersteinii</i>			x			
<i>Stichopus chloronotus</i>			x			
<i>Tripneustes gratilla</i>			x	x		

TABLE 2. Coral Density and Percentage of Substrate Surface Coverage.

<u>Transect</u>	<u>Coral Density/m²</u>	<u>% of Coverage</u>
E	0.94	0.66
F	0.78	0.27
G	0.54	0.19
H	0.49	0.56
I	1.97	2.75
J	0.95	1.38

TABLE 3. Echinoderm Density.

<u>Transect</u>	<u>Echinoderm Density/m²</u>	<u>Species Composition</u>	<u>No.</u>
D	4.67	<i>Holothuria atra</i> (only species measured)	
F	1.46	<i>Holothuria atra</i>	50
		<i>Diadema setosum</i>	13
		<i>Echinometra mathaei</i>	6
		<i>Holothuria leucospilota</i>	5
		<i>Linckia laevigata</i>	5
		<i>Actinopyga miliaris</i>	3
		<i>Tripneustes gratilla</i>	1
		<i>Holothuria</i> sp.	1
G	1.00	<i>Holothuria atra</i>	27
		<i>Actinopyga mauritiana</i>	6
		<i>Echinometra mathaei</i>	4
		<i>Diadema setosum</i>	3
		<i>Linckia laevigata</i>	3
		<i>Tripneustes gratilla</i>	1
I	0.72	<i>Holothuria atra</i>	38
		<i>Holothuria leucospilota</i>	19
		<i>Actinopyga miliaris</i>	1
		<i>Echinometra mathaei</i>	1
		<i>Stichopus chloronotus</i>	1

TABLE 4. Summary of inshore (reef-flat platform) current data, November 23 and 24, 1973. (See Fig. 5 for station location and current direction.)

<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 23, 1973						
1	ebb	327°	0.03	1050	35	025°
2	"	203°	0.01	1101	43	"
3	"	302°	0.03	1112	44	"
4	"	302°	0.07	1120	45	"
5	"	256°	0.02	1130	43	"
6	"	283°	0.06	1137	44	"
7	"	265°	0.03	1145	42	"
8	"	234°	0.07	1155	47	"
9	"	277°	0.03	1203	59	"
10	"	267°	0.05	1214	71	"
11	"	272°	0.16	1222	75	"
12	"	268°	0.19	1232	51	"
13	ebb/flood	270°	0.44	1243	90	"
14	"	298°	0.15	1250	60	"
15	flood	290°	0.10	1305	105	"
16	"	293°	0.06	1315	95	"
17	"	025°	0.04	1324	45	"
18	"	189°	0.01	1330	48	"
19	"	068°	0.05	1342	50	"
20	"	012°	0.07	1350	73	"

TABLE 4, continued

<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 23, 1973, continued						
21	flood	010°	0.08	1400	--	025°
1	"	326°	0.05	1410	--	"
1	"	225°	0.05	1500	--	"
2	"	270°	0.04	1502	61	"
3	"	225°	0.05	1508	64	"
4	"	222°	0.03	1512	66	"
5	"	183°	0.03	1519	66	"
6	"	218°	0.08	1522	70	"
7	"	218°	0.03	1527	65	"
8	"	253°	0.05	1533	72	"
9	"	254°	0.06	1538	76	"
10	"	278°	0.09	1542	100	"
11	"	272°	0.10	1547	100	"
12	"	268°	0.08	1552	95	"
14	"	292°	0.11	1602	--	040°
22	"	317°	0.11	1612	--	"
23	"	292°	0.11	1620	--	"
24	"	296°	0.08	1630	--	"
25	"	280°	0.06	1638	75	"
26	"	268°	0.09	1643	112	"
27	"	030°	0.09	1700	130	"
28	"	354°	0.08	1710	112	"
29	"	023°	0.11	1717	105	"

TABLE 4, continued.

<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 23, 1973, continued						
30	flood	352°	0.09	1725	90	040°
31	"	025°	0.13	1732	95	025°
32	"	038°	0.15	1740	80	"
33	flood/ebb	060°	0.05	1745	62	"
34	"	355°	0.06	1754	55	"
35	ebb	040°	0.09	1800	52	"
36	"	330°	0.08	1805	75	"
20	"	337°	0.05	1810	90	"
21	"	337°	0.07	1820	72	"
1	"	360°	0.09	1822	72	"
November 24, 1973						
1	exposed	--	--	0015	--	050°
2	ebb	no current	--	0020	13	"
3	"	265°	0.04	0022	17	"
4	"	306°	0.13	0035	14	"
5	"	283°	0.10	0040	15	"
6	"	276°	0.09	0042	16	"
7	"	264°	0.09	0051	18	"
8	"	252°	0.03	0055	29	"
9	"	255°	0.12	0100	47	"
10	ebb/flood	259°	0.23	0103	43	"
11	"	230°	0.67	0112	42	"
12	flood	275°	1.42	0117	20	"

TABLE 4, continued.

<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 24, 1973, continued						
14	flood	324°	0.55	0130	36	050°
37	"	198°	0.04	0144	84	"
38	"	338°	0.03	0155	64	"
39	"	338°	0.03	0200	71	"
40	"	304°	0.04	0208	59	"
41	"	277°	0.03	0214	41	"
42	"	318°	0.04	0220	19	"
43	"	238°	0.03	0230	68	"
44	"	120°	0.04	0240	34	"
44	"	133°	0.04	0250	34	"
45	"	050°	0.11	0300	25	"
46	"	198°	0.17	0315	25	"
47	"	295°	0.05	0320	30	"
12	"	100°	0.11	0322	--	"
11	"	102°	0.10	0325	--	"
10	"	160°	0.01	0330	--	"
9	"	no current	--	0335	--	"
8	"	220°	0.04	0340	--	"
7	"	204°	0.08	0345	--	"
6	"	106°	0.05	0350	--	"
5	"	122°	0.08	0355	--	"
4	"	165°	0.09	0358	--	"
3	"	122°	0.08	0403	--	"

TABLE 4, continued.

<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 24, 1973, continued						
2	flood	156°	0.07	0405	--	"
1	"	no current	--	0407	--	"
1	"	no current	--	0742	--	040°
2	"	289°	0.06	0747	--	"
3	"	284°	0.11	0752	--	"
4	"	285°	0.10	0755	--	"
5	"	263°	0.07	0800	--	"
6	"	248°	0.09	0805	--	"
7	"	280°	0.08	0809	--	"
8	"	265°	0.10	0811	--	"
9	"	258°	0.20	0816	--	"
10	flood/ebb	270°	0.28	0820	--	"
11	"	256°	0.27	0825	--	"
46	"	212°	0.17	0830	--	"
45	ebb	238°	0.15	0835	--	"
44	"	297°	0.04	0840	--	"
43	"	no current	--	0850	--	"
42	"	124°	0.02	0900	--	050°
41	"	227°	0.06	0908	--	"
40	"	260°	0.05	0912	--	"
39	"	213°	0.05	0920	--	"
38	"	252°	0.04	0930	--	"
37	"	188°	0.04	0935	--	"

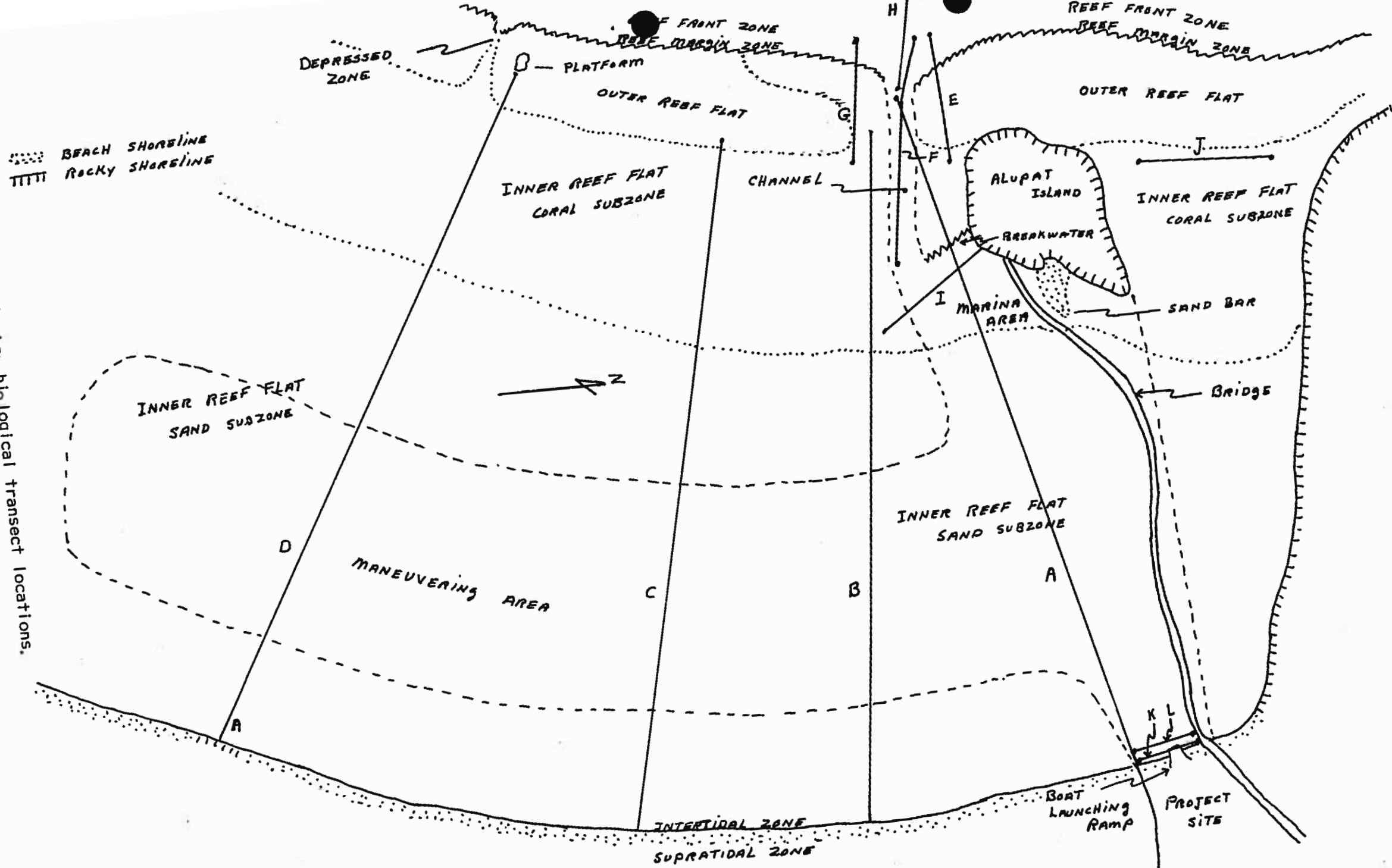
TABLE 4, continued.

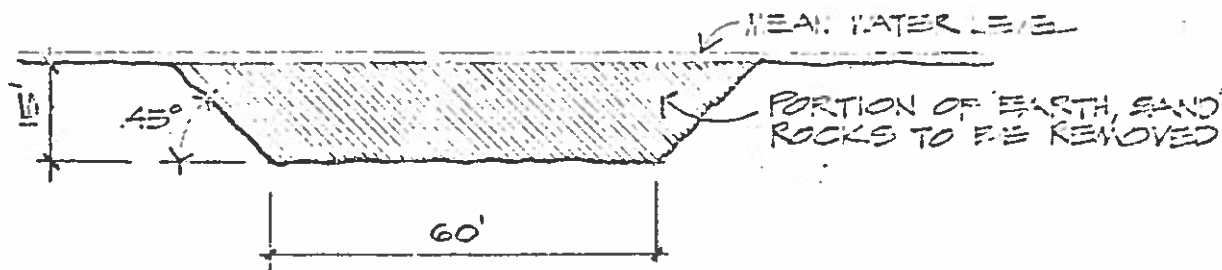
<u>Station</u>	<u>Tide</u>	<u>Magnetic Bearing</u>	<u>Speed meters/sec</u>	<u>Time</u>	<u>Depth (cm)</u>	<u>Wind Direction</u>
November 24, 1973, continued						
14	ebb	290°	0.22	0945	--	050°
48	"	305°	0.10	0952	--	"
49	"	320°	0.04	1000	--	"
50	"	336°	0.08	1012	--	"
51	"	342°	0.12	1018	--	"
52	"	346°	0.08	1025	--	"
53	"	045°	0.04	1030	--	"
54	"	no current	--	1035	--	"

TABLE 5. Summary of Offshore Current Data, December 9, 1973.

<u>Time</u>	<u>Length of Drift</u>	<u>Bearing</u>	<u>Speed m/sec</u>	<u>Wind Direction</u>	<u>Wind Speed (knots)</u>
1000	46 m	301°	0.10	118°	15-18 (gusts 25)
1100	"	305.3°	0.09	--	"
1200	"	305°	0.08	140°	"
1400	"	314.6°	0.09	144°	"
1600	"	309°	0.12	150°	"
1800	"	299°	0.08	110°	3-4
2000	"	301°	0.09	095°	5
2200	"	260°	0.08	--	"
2400	"	252°	0.08	110°	"
0200	"	219°	0.07	--	nil
0400	"	205°	0.05	--	"
0600	"	310°	0.22	--	"
0800	"	267°	0.23	100°	3-5

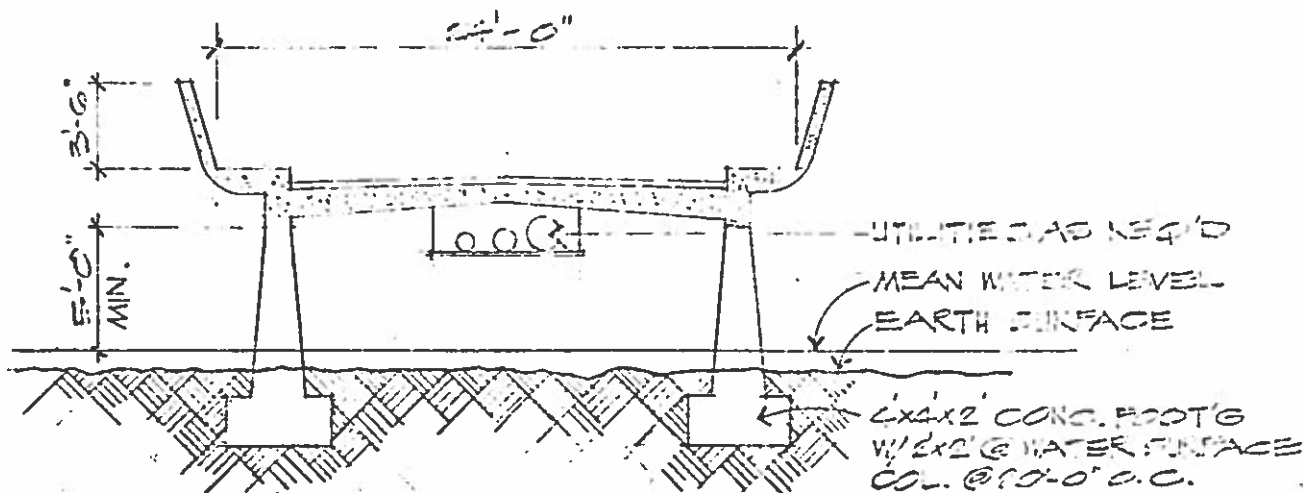
Fig. 1. Vicinity map showing biological transect locations.





CHANNEL - CROSS SECTION

SCALE: 1" = 20'-0"



BRIDGE - TYP. CROSS SECTION

SCALE: 1/8" = 1'-0"

Fig. 2. Construction details of the proposed bridge and channel.

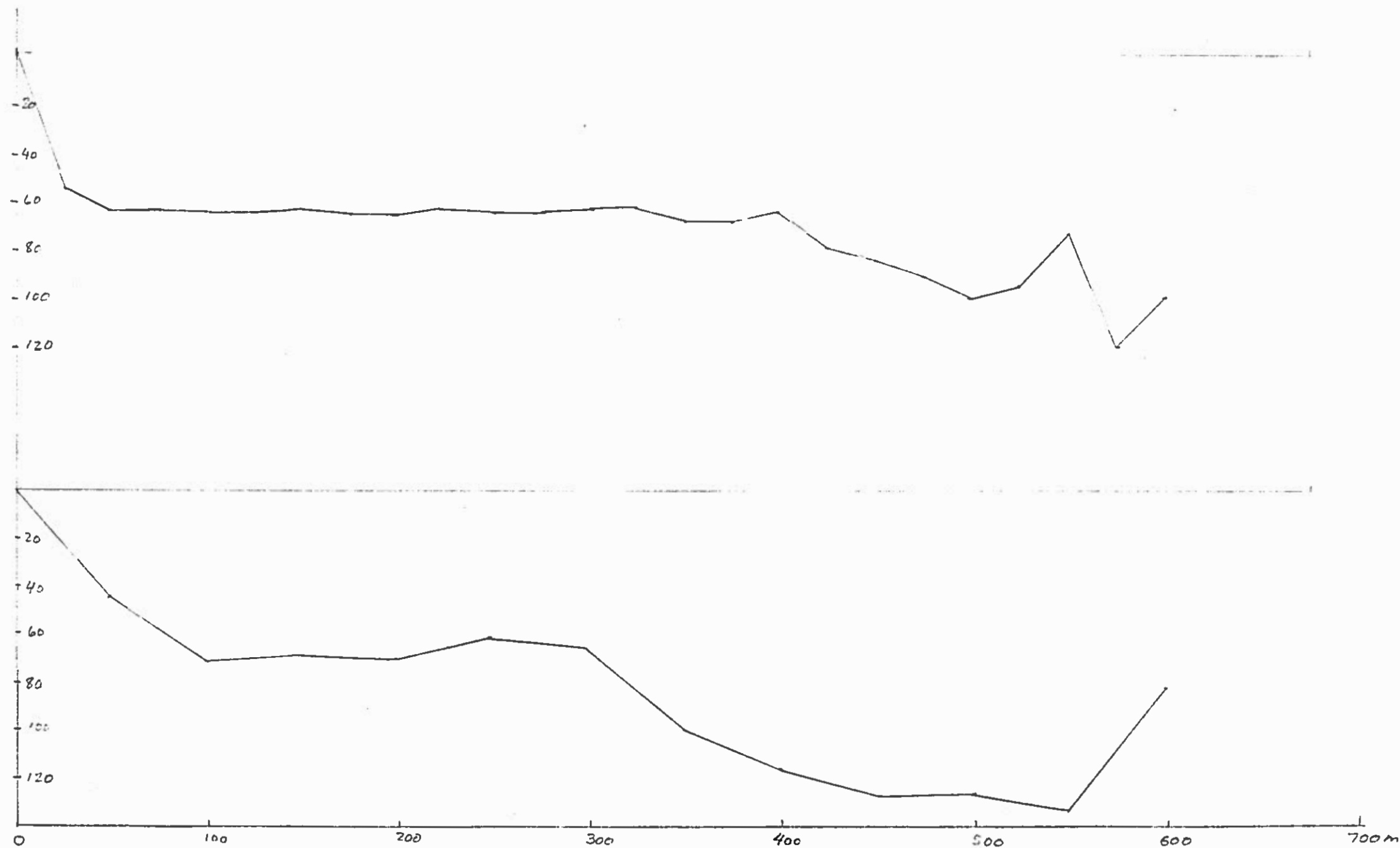


Fig. 3. Vertical profile of Transects A and B. Distance from shore in meters; depth in cm.; vertical exaggeration 125X.

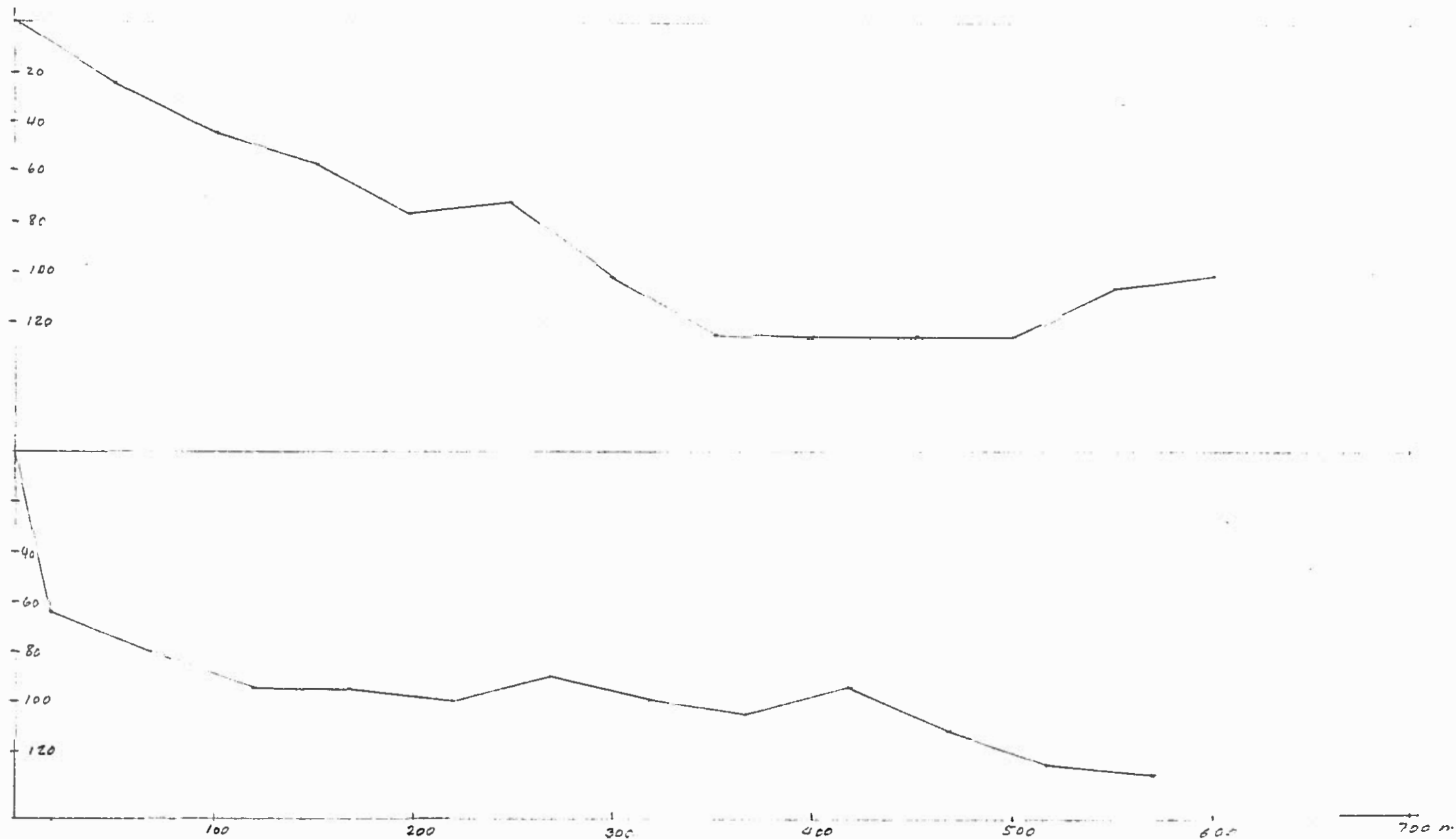
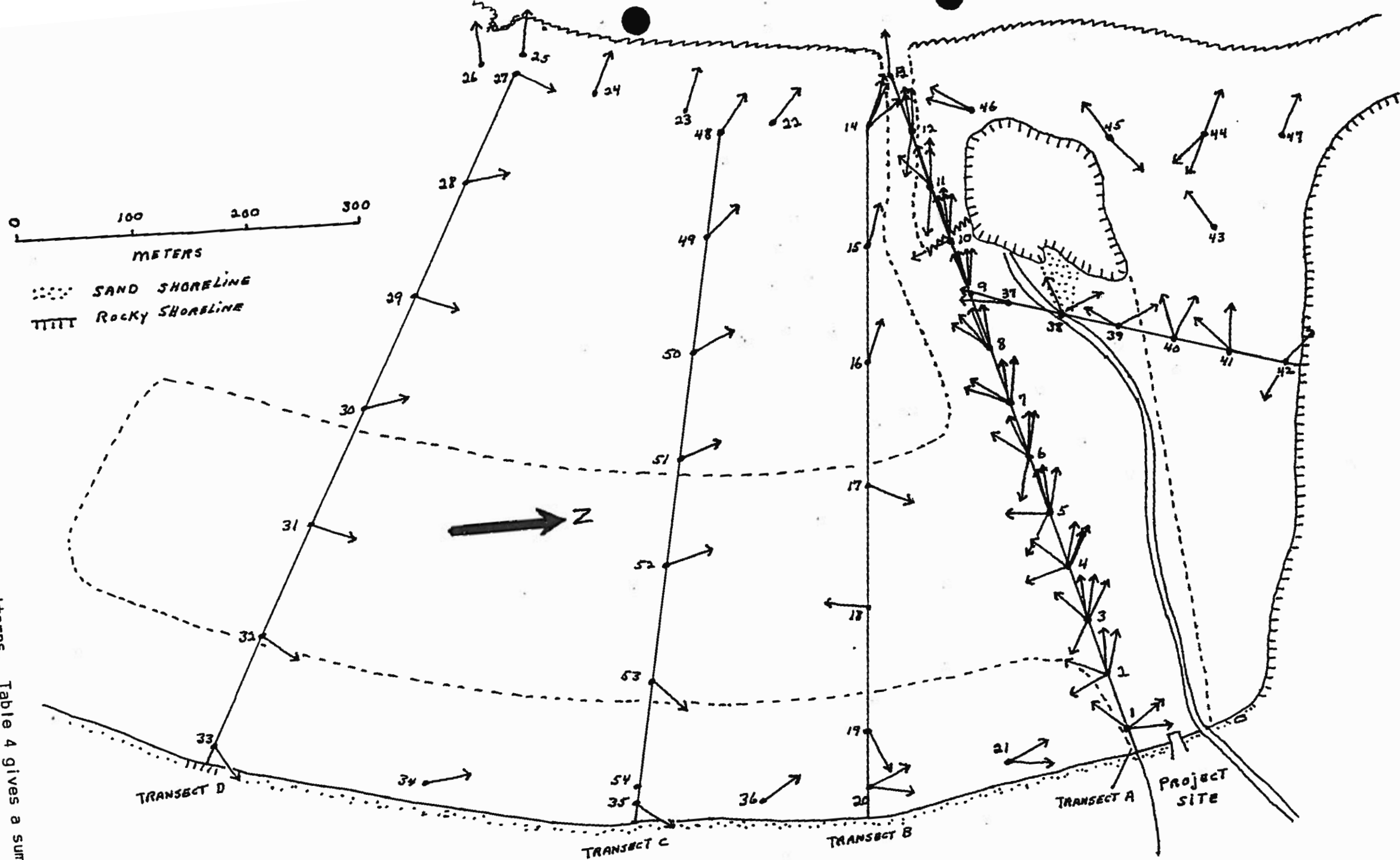


Fig. 4. Vertical profile of Transects C and D. Distance from shore in meters; depth in cm.; vertical exaggeration 125X.

Fig. 5. Inshore (reef-flat platform) current patterns. Table 4 gives a summary of the current data.



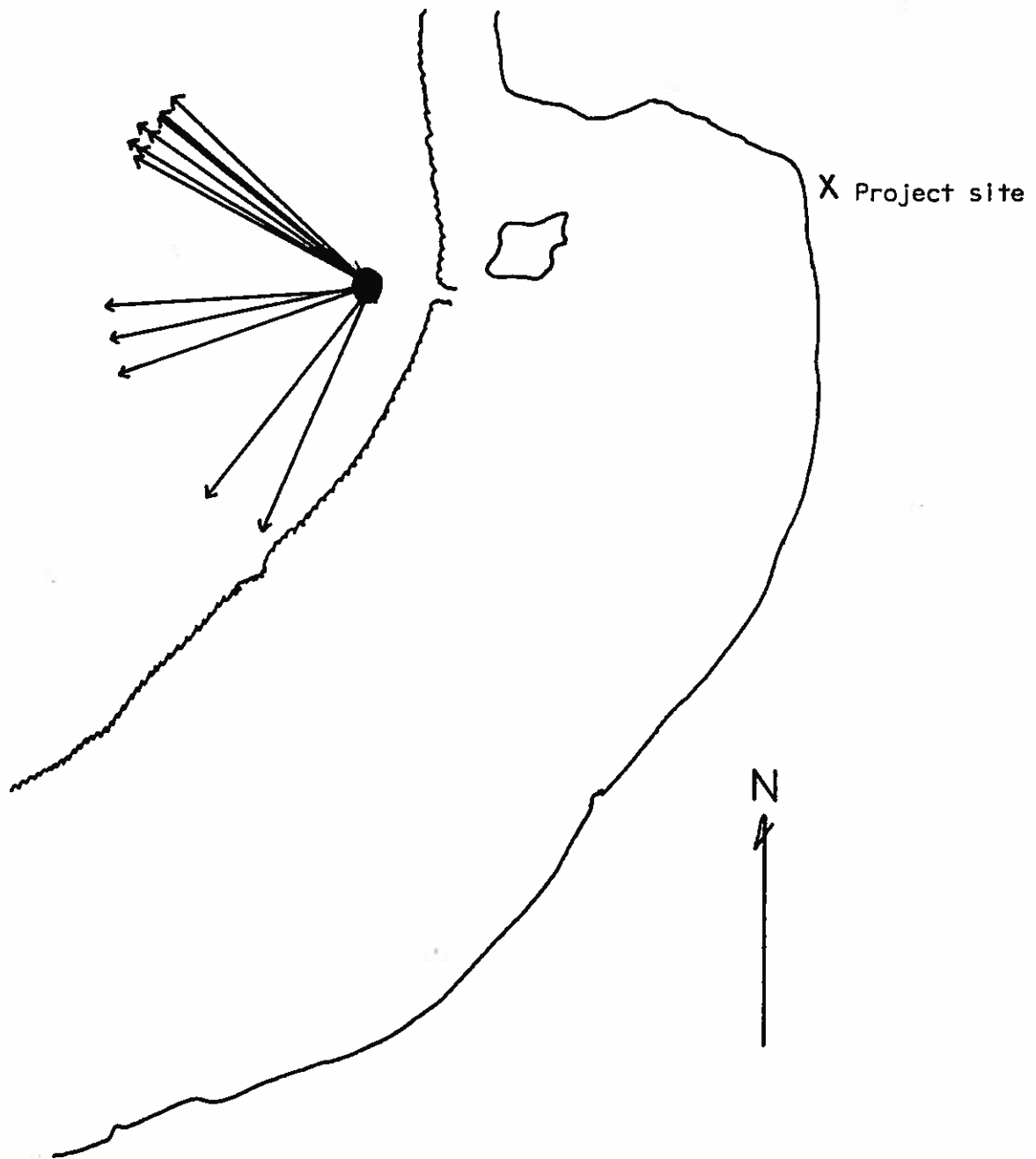


Fig. 6. Offshore current patterns for 24-hour current study opposite the mouth of the proposed channel through the reef margin. Station is located 100 meters seaward of reef margin at the 25-foot contour. Project site is shown at point X. Table 5 gives a summary of the current data. (Scale: 117 meters per centimeter.)

APPENDIX

Fishes at the Proposed Sleepy Lagoon Development Site

R. S. Jones

A total of 86 species of fishes were observed on the reef flat, reef front, reef margin, and submarine terrace zones (see checklist). In general, there were very few fishes encountered on the inner reef-flat sand subzone. Most of the 39 species which occurred on the reef flat were observed in the outer coral subzone. The greatest diversity (67 species species) of fishes was encountered on the reef front, reef margin, and submarine terrace zones.

<u>Checklist of Fishes Observed</u>	<u>Submarine Terrace, Reef Front, and Channel</u>	<u>Reef Flat</u>
ACANTHURIDAE		
<i>Acanthurus glaucopareius</i>	x	
<i>A. lineatus</i>	x	
<i>A. nigrofuseus</i>	x	x
<i>A. triostegus</i>	x	x
<i>Ctenochaetus striatus</i>	x	
<i>Naso literatus</i>	x	
<i>N. unicornis</i>	x	
APOGONIDAE		
<i>Apogon novemfasciatus</i>		x
<i>Apogon</i> sp.	x	
BALISTIDAE		
<i>Balistapus undulatus</i>	x	
<i>Rhinecanthus aculeatus</i>		x
<i>Sufflamen chrysoptera</i>	x	
BLENNIIDAE		
<i>Istiblennius coronatus</i>	x	

Appendix, continued.

<u>Checklist of Fishes Observed</u>	<u>Submarine Terrace, Reef Front, and Channel</u>	<u>Reef Flat</u>
BLENNIIDAE, continued		
<i>Meiacanthus atrodorsalis</i>	x	
<i>Petroscirtes mitratus</i>		x
<i>Runula tapeinosoma</i>	x	
<i>Salarias fasciatus</i>		x
BOTHIDAE		
<i>Bothus mancus</i>		x
CANTHIGASTERIDAE		
<i>Canthigaster bennetti</i>	x	
<i>C. cinctus</i>	x	
<i>C. solandri</i>	x	x
CHAETODONTIDAE		
<i>Chaetodon auriga</i>	x	x
<i>C. citrinellus</i>	x	x
<i>C. ephippium</i>		x
<i>C. lunula</i>	x	x
<i>C. reticulatus</i>	x	
<i>C. trifasciatus</i>	x	
CIRRHITIDAE		
<i>Cirrhitus pinnulatus</i>	x	
<i>Paracirrhites forsteri</i>	x	
FISTULARIIDAE		
<i>Fistularia petimba</i>	x	
GOBIIDAE		
<i>Oplopomus</i> sp.		x
HOLOCENTRIDAE		
<i>Holocentrus sammara</i>		x
<i>H. tieve</i>	x	
LABRIDAE		
<i>Anampses caeruleopunctatus</i>		x
<i>Cheilinus fasciatus</i>	x	
<i>C. rhodochrus</i>	x	
<i>C. trilobatus</i>	x	
<i>Coris aygula</i>	x	
<i>C. gaimardi</i>	x	
<i>Gomphosus varius</i>	x	
<i>Halichoeres hortulanus</i>	x	
<i>H. margaritaceus</i>	x	x

Appendix, continued.

<u>Checklist of Fishes Observed</u>	<u>Submarine Terrace, Reef Front, and Channel</u>	<u>Reef Flat</u>
LABRIDAE, continued		
<i>Halichoeres marginatus</i>	x	
<i>H. trimaculatus</i>		x
<i>Hemigymnus fasciatus</i>	x	
<i>H. melapterus</i>	x	x
<i>Labroides dimidiatus</i>	x	x
<i>Macropharyngodon pardalis</i>	x	
<i>Stethojulis axillaris</i>	x	x
<i>S. linearis</i>	x	x
<i>Thalassoma amblycephalus</i>	x	
<i>T. hardwickei</i>	x	x
<i>T. lutescens</i>	x	
<i>T. purpureum</i>	x	
<i>T. quinquevittata</i>	x	
LUTJANIDAE		
<i>Lethrinus microdon</i>	x	x
<i>Lutjanus vaigiensis</i>	x	
<i>Scolopsis cancellatus</i>		x
MUGILLIDAE		
<i>Mugil sp.</i>		x
MULLIDAE		
<i>Parupeneus barberinus</i>		x
<i>P. crassilabrus</i>	x	
<i>P. multifasciatus</i>	x	x
<i>P. pleurostigma</i>	x	
OSTRACIONTIDAE		
<i>Ostracion meleagris</i>		x
POMACENTRIDAE		
<i>Abudefduf amabilis</i>	x	x
<i>A. glaucus</i>		x
<i>A. lacrymatus</i>	x	
<i>A. leucopomus</i>	x	x
<i>A. septemfasciatus</i>		x
<i>Dascyllus aruanus</i>		x
<i>D. trimaculatus</i>	x	
<i>Pomacentrus albofasciatus</i>		x
<i>P. jenkinsi</i>	x	
<i>P. nigricans</i>	x	
<i>P. traceyi</i>	x	
<i>P. vaiuli</i>	x	

Appendix, continued.

<u>Checklist of Fishes Observed</u>	<u>Submarine Terrace, Reef Front, and Channel</u>	<u>Reef Flat</u>
SCARIDAE		
<i>Calotomus spinidens</i>	x	
<i>Scarus lepidus</i>	x	x
<i>S. sordidus</i>	x	x
SERRANIDAE		
<i>Cephalopholis urodelus</i>	x	
<i>Epinephalus merra</i>	x	
SIGANIDAE		
<i>Siganus argenteus</i>	x	
<i>S. spinus</i>		x
SYNGNATHIDAE		
<i>Corythoichthys intestinalis</i>	x	x
SYNODONTIDAE		
<i>Synodus</i> sp.	x	
ZANCLIDAE		
<i>Zanclus cornutus</i>	x	x
TOTALS: 86 spp.	67 spp.	39 spp.