

**ENVIRONMENTAL ASSESSMENT  
for Construction of  
Mooring Buoys in Tumon Bay**

**Prepared For  
Coral Reef Water Tours**

**Prepared by  
Pacific Basin Environmental consultants, Inc.**

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## **Introduction**

### **A. Study Purpose**

The purpose of this study is to provide the local and federal government with the necessary baseline information and environmental awareness to properly evaluate the placement of several mooring buoys in Tumon Bay, Guam. One of the buoys already exists and will require an "After the Fact Permit." These buoys will be used to secure two vessels owned by Coral Reef Water Tours Inc. and operated as Sunset Cruises.

### **B. Study Area**

The study area is located in Tumon Bay, Guam, (Figure 1). Sunset Cruises operates two catamarans in the shallow lagoon waters of Tumon Bay in the evening for sunset/dinner cruises. Cruises are for a short, 2.5 hours duration along the shoreline throughout the lagoon. Cruise plans for the future include moonlight cruises between 8:30 pm and midnight.

### **C. Project Description**

There are two elements regarding this project. The first element is to make legal the existing mooring which has been used since 1987 (Figure 2). The second element concerns the application for four (4) additional mooring systems which are divided into nearshore and offshore components. (Refer to Section II-B for details). In general terms these systems are designed to provide secure moorings for loading and unloading operations on the beach and safe mooring offshore during normal and heavy weather conditions.



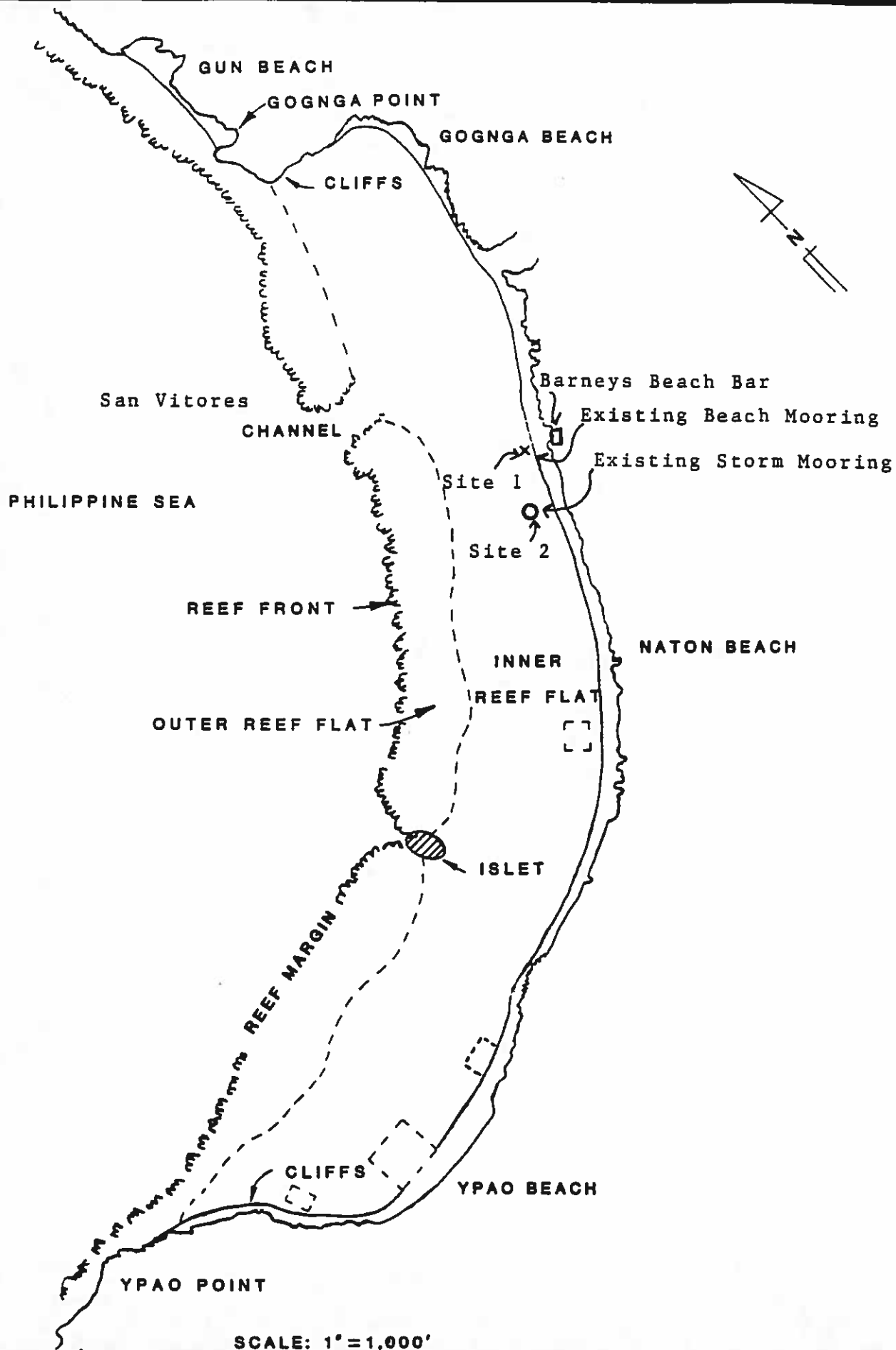


Figure 2. Location of existing mooring systems in Tumon Bay, Guam.

## **II. Project Details**

### **A. Existing Conditions**

#### **1. Sunset Cruises in Tumon Bay**

Presently, there are only two sunset cruise boats operating in Tumon Bay, both owned and operated by Coral Reef Water Tours Inc. One of the boats is 38 ft long 15'6" ft wide with a loaded weight of 7,500 lbs and powered by twin 40 hp Johnson outboards. The other boat is substantially larger at 65 ft long and 45 ft wide with a loaded weight of 30,800 lbs (Figures 3 and 4). This vessel is powered by twin 110 hp Johnson outboards.

#### **2. Loading and Unloading on the Beach**

Both vessels are pulled up on the beach each morning just to the south of Barney's Beach Bar property (Figure 2). Coral Reef Water Tours has a concession agreement with Barney's for the southern corner of the Beach Bar property. On this site is a storage and work shed where employees perform various service tasks on the vessels. Water is brought to the vessels from the storage/work site.

Vessels remain on the beach until early evening. Buses unload passengers at Matapang Beach and they board the vessels via boarding planks from the beach. The vessels are then pushed out and maneuvered into deeper water usually operating in the northern, deeper-water sector of the lagoon. Depending on water depth (tide), these cruise boats can operate throughout the lagoon. The vessels return to the beach when the cruise is over and unload passengers in the same manner. Passengers are

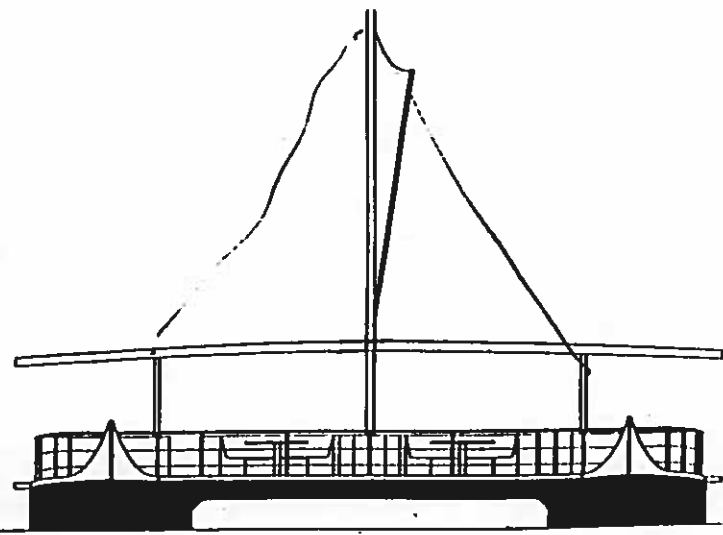
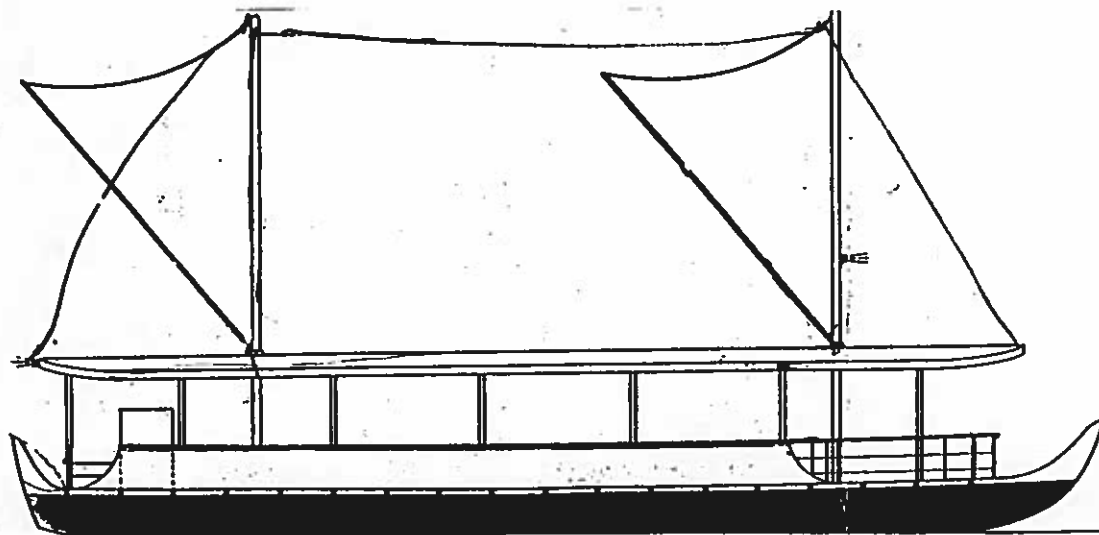
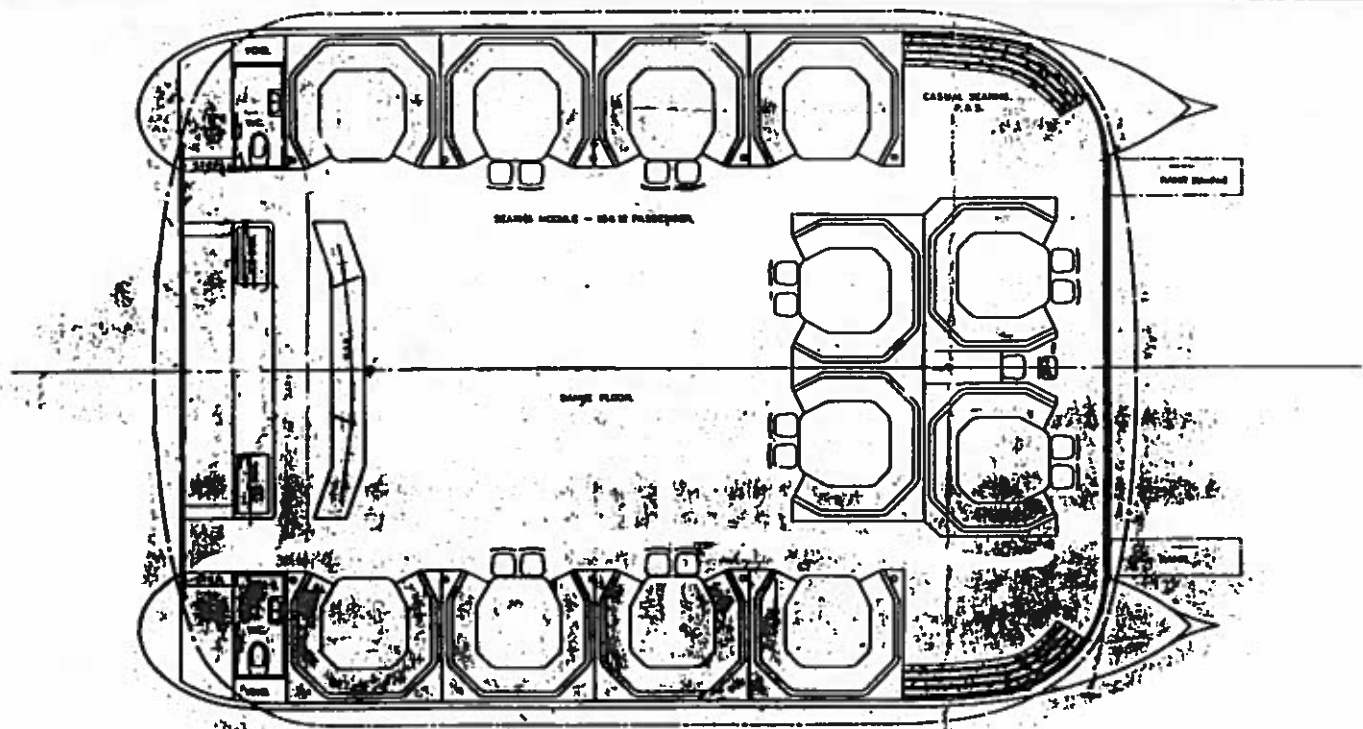


Figure 3. Schematic of Sunset Cruise Boat. Length 67 ft 1 in.

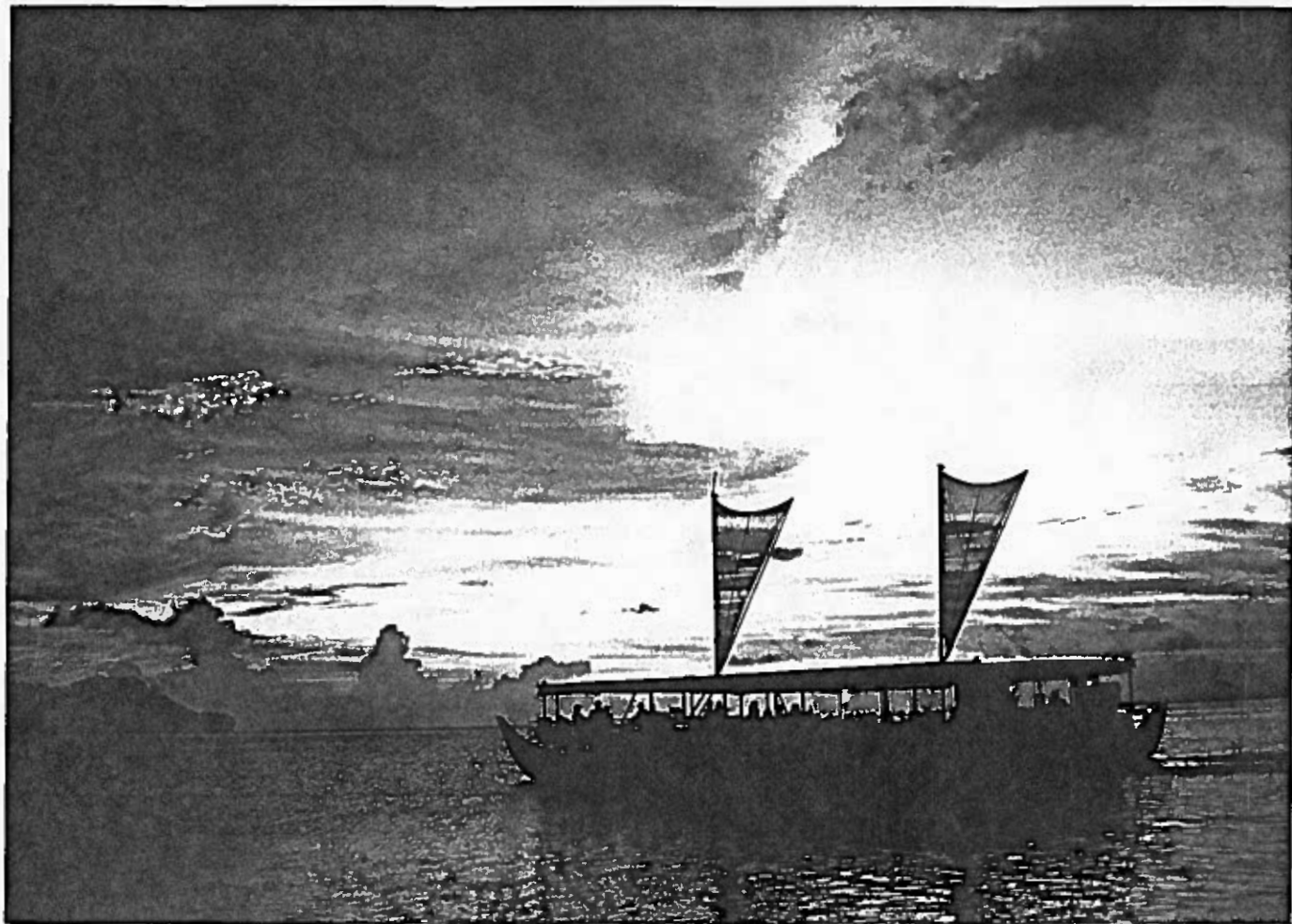
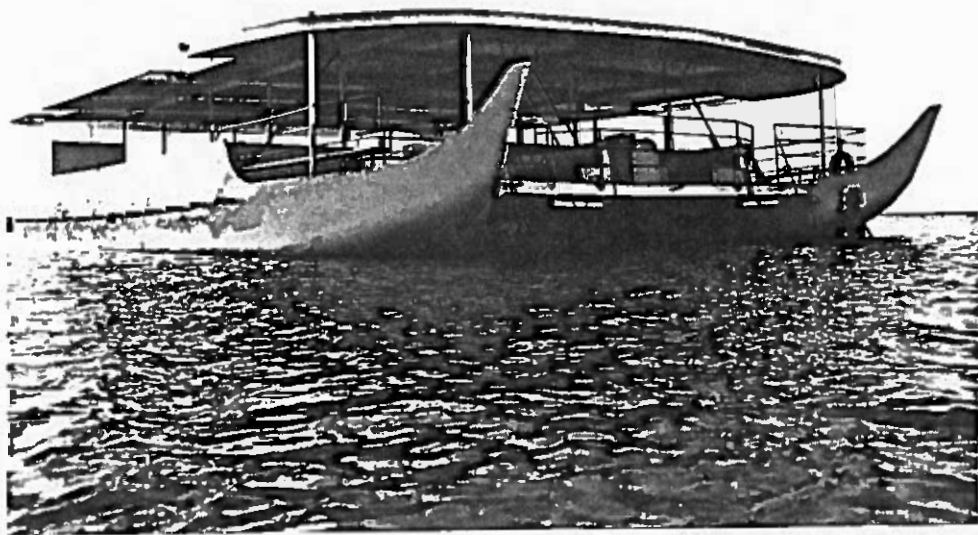


Figure 4. Photos of the Sunset Cruise Boat.

then bussed away to their hotels.

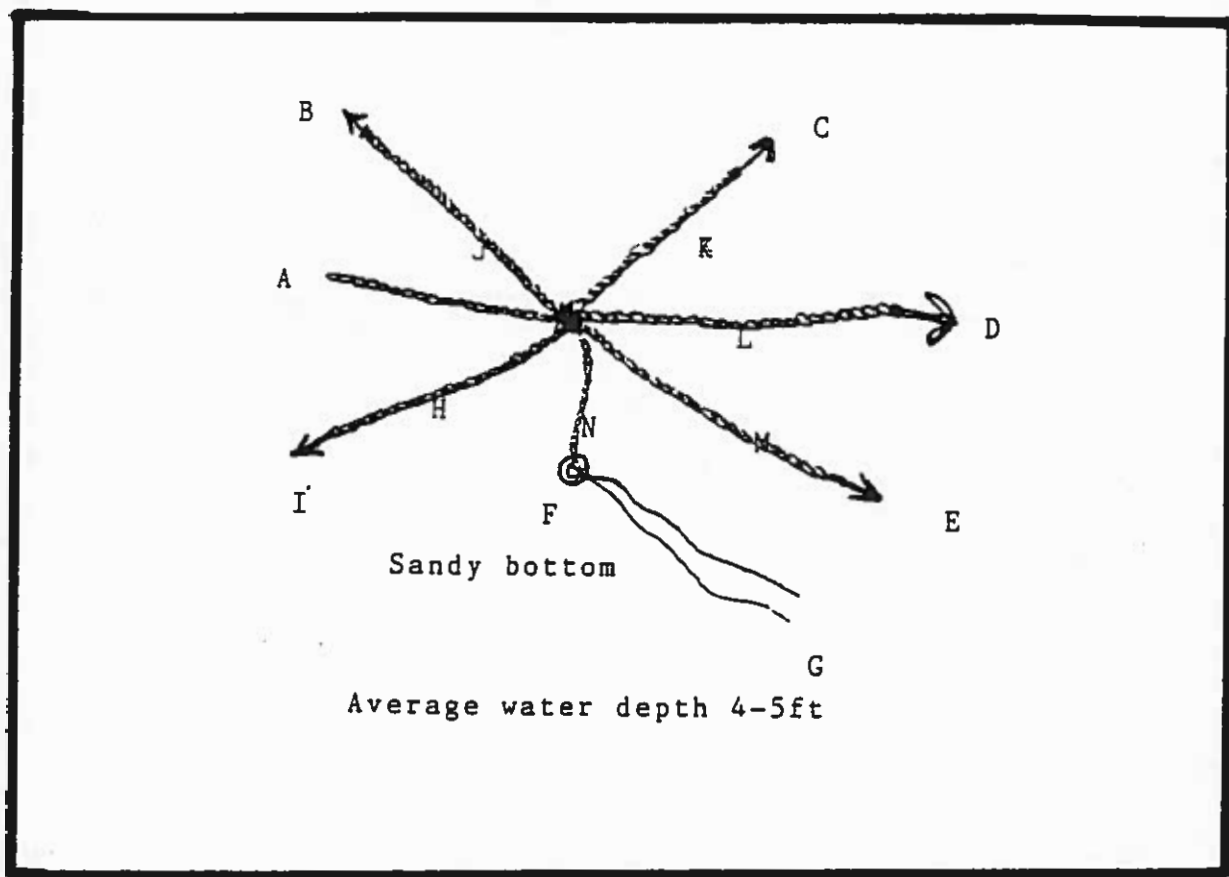
### **3. Mooring and Anchoring**

#### **a. Normal Weather Conditions**

Under normal weather conditions the vessels remain pulled up on the beach where service and loading/unloading operations take place. There is an existing mooring system in place presently used for the large vessel (Figure 2). This mooring system utilizes two large anchors placed in deeper water approximately 150 ft offshore with chains attached. Mooring lines are secured to each of the chains and tied to each of the twin hulls aft. Two lines forward on each hull are secured to chains that have been buried under the beach sand. One line (south) is secured to a 100 lb Bruce anchor buried three feet under the sand above the high tide line. The other chain (north) is secured to a 2 inch steel pole driven into the sand above the high tide line. This chain is buried at least three feet below the sand. Chain under the sand does become exposed at times, usually after heavy surf action when the boat pulls hard while moored. Chain is exposed in the intertidal zone for a few feet. The smaller vessel simply throws a small 20 lb Danforth anchor off the stern and a similar anchor off the bow onto the beach near the tide line. These two anchors are adequate to hold the smaller vessel.

#### **b. Storm Weather Conditions**

During storm weather conditions the larger vessel is secured to the existing (unpermitted) storm mooring (Figure 2). This mooring is a five-point system (Figure 5). The mooring buoy is a typical typhoon



- A : 50 ft 5/8" chain without anchor .(May be used to moore boat )
- B : 120 lbs Bruce anchor dug in to sand.
- C : 120 lbs Bruce anchor dug in to sand.
- D : 500 lbs Stockless anchor laying on the sand .
- E : 120 lbs Bruce anchor dug in to sand.
- I : 120 lbs Bruce anchor dug in to sand.
- H,J,K,L,M,N : 5/8" chain 50 to 60 ft long connected to anchors by schackles and connected on their free ends by schackles to each other and to chain N.
- N : 40 ft 5/8" chain connected to mooring buoy .
- F : Mooring bouy .
- G : Mooring lines (2 units).

Figure 5. Detail of existing storm mooring in Tumon Bay, Guam.

mooring system. There are four 120 lb Bruce Anchors buried in the sand in water three to four feet deep (Figure 5). Additionally, a single 500 lb stockless anchor is lying on the sand in four feet of water. A single anchorless chain also exists connected to the other five chains with anchors. Six separate 50-60 ft lengths of 5/8" chain connect to the anchors by shackles and all six chains connect together to a single 40 ft, 5/8" mooring chain. The mooring chain is then attached to a float used only to locate the chain. Two mooring lines (rope) are connected directly to the mooring chain by thimbles and shackles. All shackle bolts are secured by safety wire or by flattening the bolt threads.

This storm weather mooring system was surveyed on July 8, 1988 by a licensed marine surveyor and found to be adequately sized for the large vessel, Proa III.

#### **B. Mooring Requirements**

##### **1. Number and Location of Mooring Systems**

###### **a. Nearshore**

Two (2) nearshore mooring systems are required for Coral Reef Water Tours Sunset Cruise vessels (Figure 6) (one each for each vessel). However, the systems are being redesigned to eliminate chains under the beach sand and length of chain on the surface, both in nearshore intertidal water. Existing anchors and chain offshore will remain (Refer to mooring design details in Section II-B below). Both of these mooring systems will secure the vessels on the beach during service periods and for loading/unloading operations.

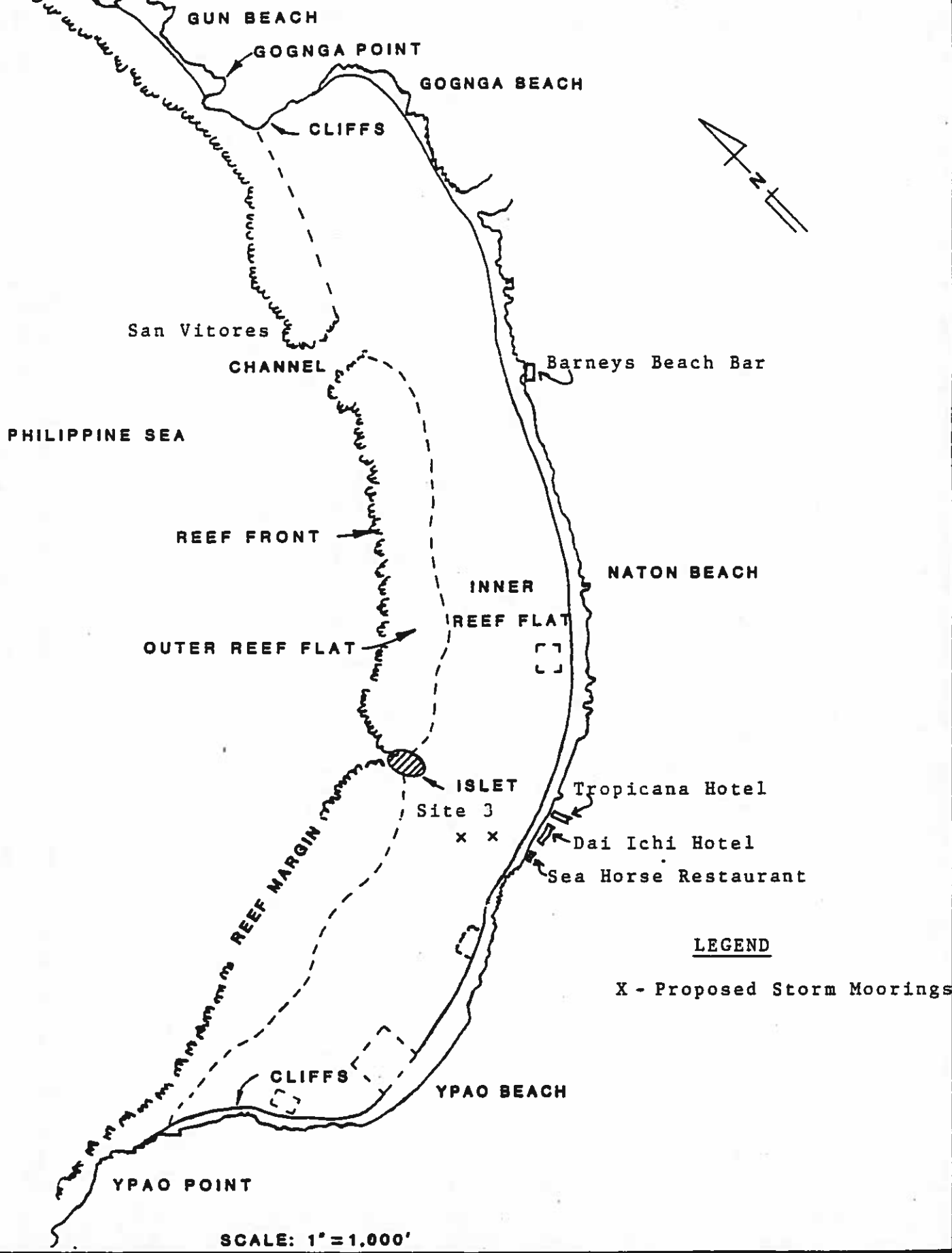


Figure 6. Location of proposed mooring systems in Tumon Bay, Guam.

## **b. Offshore**

Three (3) offshore moorings are required (Figure 6) in order to moor the vessels in periods of heavy weather or during storms. One of these mooring systems is already in place. Two additional systems are therefore required.

## **2. Mooring Systems Design**

### **a. Nearshore**

The nearshore mooring system will be modified to remove the existing chains under the beach sand and replace them with buried blocks in the intertidal zone. Three (3) concrete blocks measuring 3'x3'x3' (27 ft<sup>3</sup>) and weighing 4,000 lbs will be buried four (4) feet deep under the sand in the intertidal zone (Figure 7A and 8). A short length of 5/8" chain will be shackled to a stainless steel hook in the concrete block and will emerge above the substrate for a few feet. A mooring line will be shackled to the chain and secure the vessel during service and loading/unloading operations.

Three concrete blocks in the nearshore zone and three anchors offshore (two already exist) will provide adequate mooring security while the vessels are being serviced or loaded/unloaded. We have eliminated one nearshore block and offshore anchor from the original design since we believe that two vessels can be secured adequately if they can be moored side-by-side.

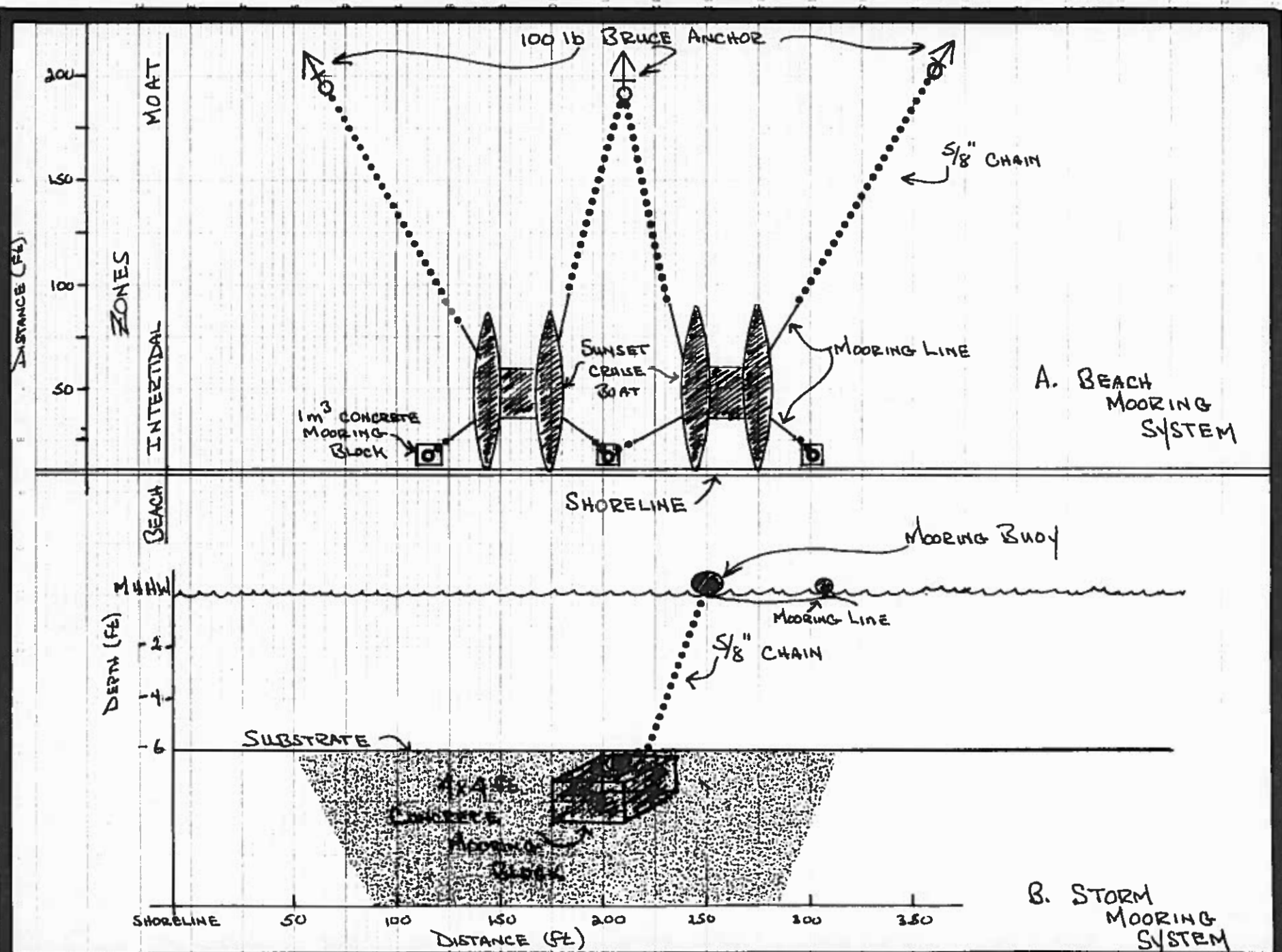


Figure 7. Detail of proposed mooring systems. A. Beach mooring system.

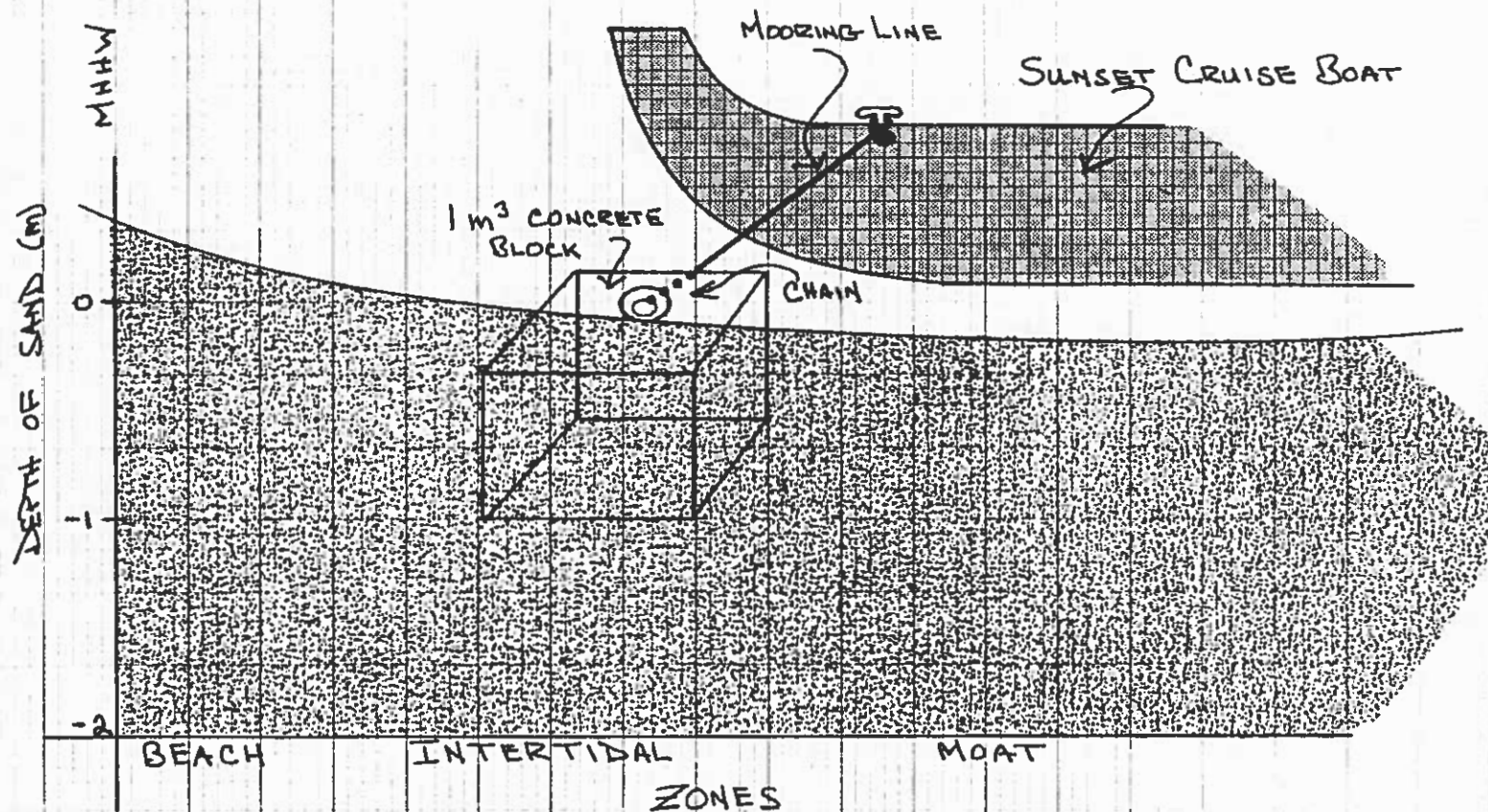


Figure 8. Detail of beach mooring system.

b. Offshore

The existing anchors and chain layed offshore will be retained to secure the stern of each vessel (Figure 7A). Additionally, one similar anchor/chain system will be placed so that both vessels can be moored simultaneously.

Two additional storm moorings are required in order to secure the vessels during heavy or hazardous weather conditions. Both of these moorings will be placed in the same general area protected from high surf by the small islet on the outer reef-flat (Figure 6). These moorings will be placed in shallow water directly in front of the Sea Horse Restaurant.

Each of these moorings will be single concrete blocks measuring 4'x4'x4' (64 ft<sup>3</sup>) and weighing 9,600 lbs. The blocks will be buried under the sand with the chain protruding and buoyed for location (Figure 7B).

3. Construction Methodology

Each of the five (5) mooring blocks will be buried in the sand below grade. In the case of the nearshore mooring blocks, construction could take place during a normal low tide period. Placement of the offshore mooring block will take place during a minus tide day when water depth is minimal.

A backhoe will be utilized to dig the hole where the blocks are to be placed. Excavated sand will be piled immediately beside the hole. The backhoe will then pick up each block from the delivery vehicle and carry it to the proper site placing it in the hole and positioning it in place. Sand

will then be filled back into the hole covering the block completely. Excess sand and rubble will be spread evenly over the surface at the mooring site.

Volume of excess sand is calculated at approximately 3 yd<sup>3</sup> which is minimal when spread out over the mooring block. This volume will be divided fairly/evenly between the two different sites (1) Beach mooring and (2) Storm mooring. Volume by location is 1.5 yd<sup>3</sup> at each site.

The ACOE has a policy that a maximum of 10y<sup>3</sup> can be dredged without a permit. However, notification must be prepared that such action will take place and under what condition the dredging will take place.

Since the holes can be dug in extremely shallow water, or possibly during dry conditions, and since no coral resources are located nearby the mooring locations, no silt protection is being proposed.

### **III. Environment Without the Project**

#### **A. General Description**

The project site (Tumon Bay) is located on the west coast of Guam between Ypao and Bijia Point (south and north) respectively (Figures 1 and 2). Tumon Bay is characterized by a wide and shallow reef-flat. Water depths on the reef-flat range between zero and two feet below Mean Lower Low Water (MLLW). A sandy beach extends along most of the shoreline.

Reefs and subtidal features within Tumon Bay vary depending on the particular reef subzone. Three distinct reef subzones exist within the lagoon at Tumon Bay: Intertidal, Inner Reef-flat and Outer Reef-flat.

Intertidal Zone - The intertidal zone along Tumon Bay is mostly unconsolidated sand and coral-algal-mollusk rubble. A considerable portion of the sand portion of the unconsolidated beach material consists of foraminifera tests brought to shore by wave action and currents. Bare limestone comprises the northern and southern extremes of Tumon Bay with well developed nips and cuts at the cliffline. Live coral is conspicuously absent throughout the intertidal zone. However, thick mats of the alga Enteromorpha clathrata exist along the shoreline throughout this bay. This alga thrives in the warmer nearshore waters particularly in the north-central sector of the bay where reduced salinity is caused by fresh water seepage at the shoreline.

Inner Reef-flat Zone- Typically called the moat, this zone is considerably wider than the outer reef-flat zone ranging between 350 and 380 m (1148-1247 ft). Localized areas of bare rock are common particularly where the outer reef-flat begins. However, most of this zone is comprised of unconsolidated sediments of varying thickness of a meter or more near the beach to only a thin veneer near the outer reef-flat zone. Sand, gravel, coral-algal-mollusk rubble and small boulders make up the sediments here. The entire inner reef-flat zone is relatively flat with a few cracks, holes, low rubble mounds and shallow, bowl-shaped depressions. Deepest water in this zone is at about mid-point, approximately 150m (492 ft) from shore. Corals exists in the inner reef-flat zone but primarily near the outer portion. Corals are usually

associated with large rocks which have been tossed up onto the reef-flat from deeper water by storms.

Outer Reef-Flat Subzone - This subzone of the Tumon reef-flat varies considerably in width and is exposed during lower tides. At the natural channel near Naton Beach the outer reef-flat disappears completely because of the presence of several shallow channels. Unconsolidated sediments are nearly absent along the seaward part of this region except in small shallow pools. The inner part usually has scattered boulders over the surface and large boulder tracts form in some areas. The source of these boulders is the reef margin and reef front where rocks and living corals are broken loose and worked shoreward by storm waves. A large accumulation of such boulders forms the basis for the small islet developing on the outer reef-flat between Naton and Ypao beaches.

#### B. Marine Flora and Fauna

##### Site 1

This site incorporates the two beach mooring/staging sites immediately south of Barneys Beach Bar (Figure 2). This is the same location where loading/unloading and service takes place at the present time.

The nearshore environment is sandy with scattered rubble and isolated small boulders. This zone includes the intertidal area where salinity is reduced because of fresh water intrusion from the water lens system. The sea cucumber, Holothuria atra, is abundant in this zone. The fresh water tolerant alga Enteromorpha clathrata is also abundant

nearshore because of the fresh water leaching out from the lens system. Other marine life is extremely limited and there are no live corals. The only other alga is Hypnea pannosa occasionally found in the lagoon nearshore. Depth of sand is at least three feet and could be deeper (5 to 6 feet) (Figures 9 and 10). Fish are rare in this region and limited to a few wandering speices like mullet and isolated wrasses. Occasionally, a puffer, blenny or damselfish can be observed, usually in the vicinity of a rock.

The offshore environment associated with this site is similar in many ways but quite different in others. The marine flora and fauna is very similar with an abundance of Holothuria atra. Fishes are also similar with an occasional triggerfish. Algae are the same with the addition of Caulerpa sertularioides, Halimeda opuntia and the coralline algae Porolithon onkoides. The biggest difference is the substrate. Here, sand exists only as a thin veneer over hard pavement. This area is also much shallower than the nearshore zone. The existing anchoring systems (anchors and chain) will be retained since depth of sand is not adequate to bury a concrete block.

#### Site 2.

This site is the location of the exisiting storm mooring (Figure 2). This mooring is situated in water 2-3 ft deep approximately 100 ft from the shoreline.



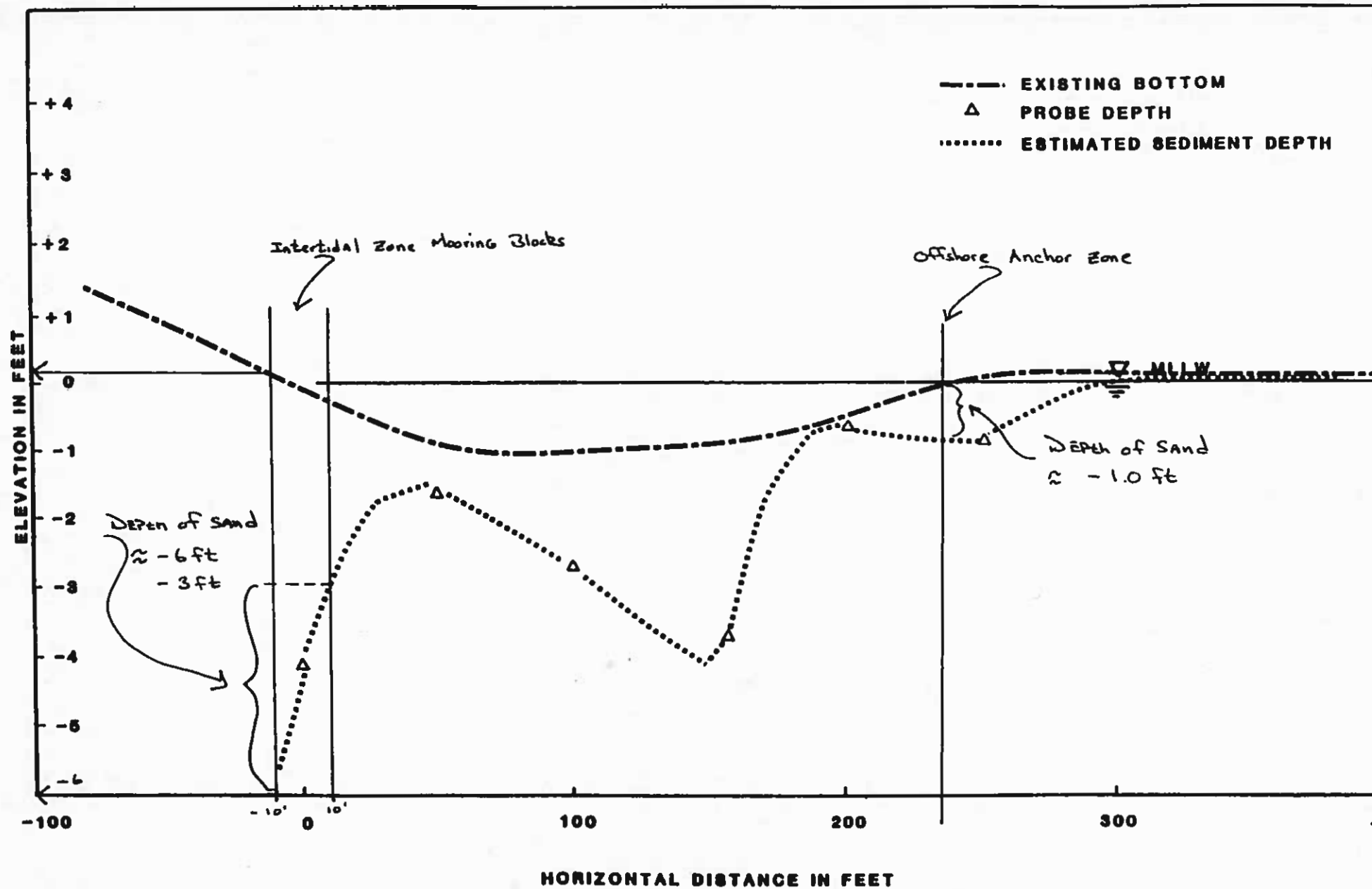


Figure 10. Nearshore sediment profile No. 9 at Site 1.

The marine environment is comprised of a sandy bottom with scattered rocks and rubble. Sand depth in this region is between two and four feet (Figures 10,11 and 12). The sea cucumber Holothuria atra is common throughout this area. Fish are practically absent except for migrating forms like mullet and small jacks.

The surface of the limestone pavement is usually covered with a turf-like mat of filamentous algae. Foraminifera are abundantly distributed throughout this algal mat and are the main source of the buff-colored sand found on the reef-flat and beach.

### 3. Site 3

This site is the proposed location for two storm moorings (Figure 6). The mooring zone is situated between the shoreline in front of the Sea Horse Restaurant (South Naton Beach) and the islet on the outer reef-flat.

The marine environment is very uniform with a sandy bottom throughout. Rubble is non existent and isloated larger boulders are rare. Water depth is adequate for mooring these vessels even at a lower low tide. Tide would usually be even higher during storms since a storm brings a greater volume of water onto the shallow reef-flats with higher waves. Depth of sand is a minimum of 1.2 ft and probably deeper (Figures 9 and 12).

The sea cucumber Holothurea atra was rare in this zone as was most other life forms. There were no corals. Algae are scattered and rare. Leathery stalks of Avrainvillea lacerata can be found in sparse

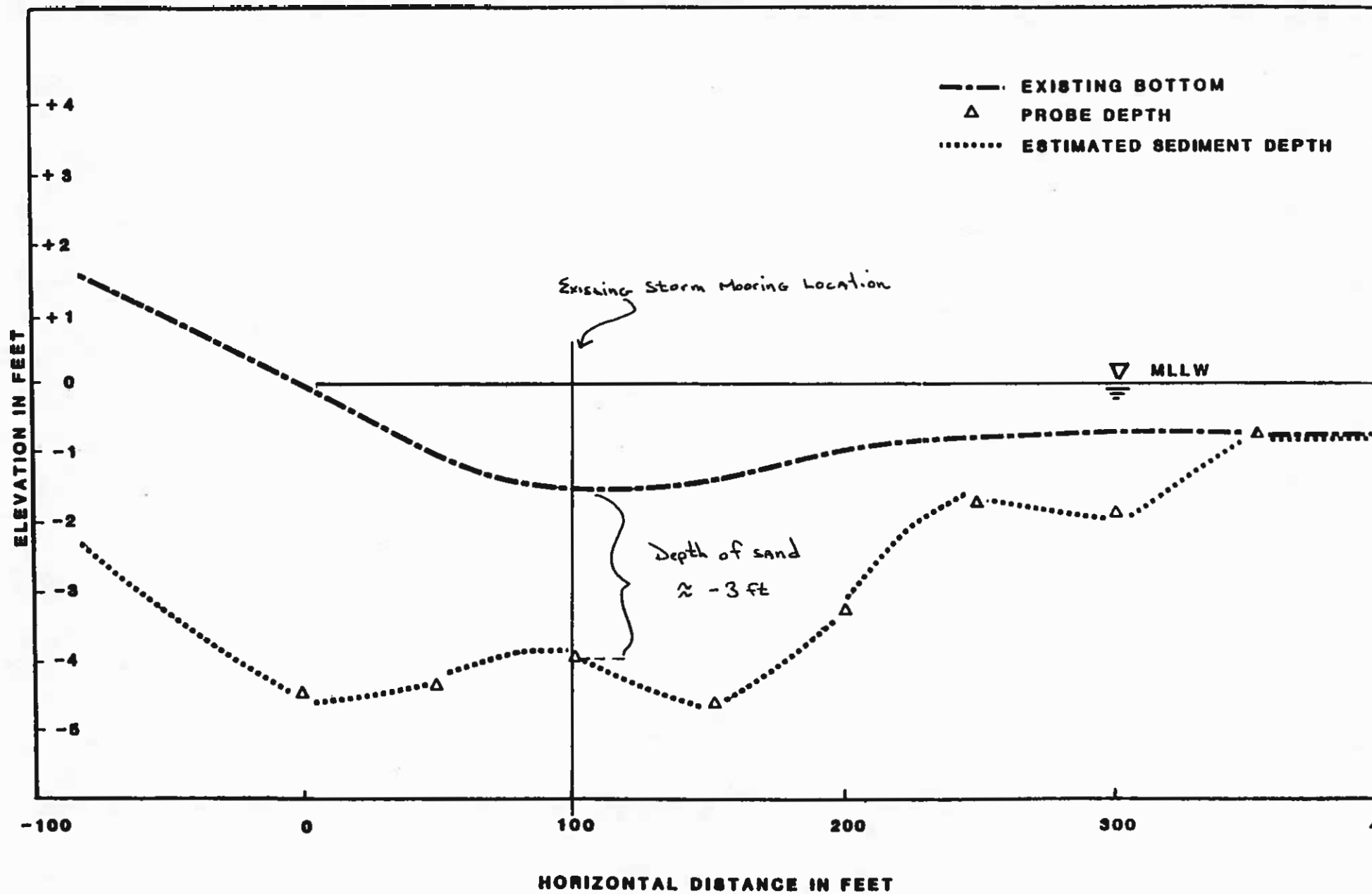


Figure 11 Nearshore sediment profile No. 10 at Site 2.

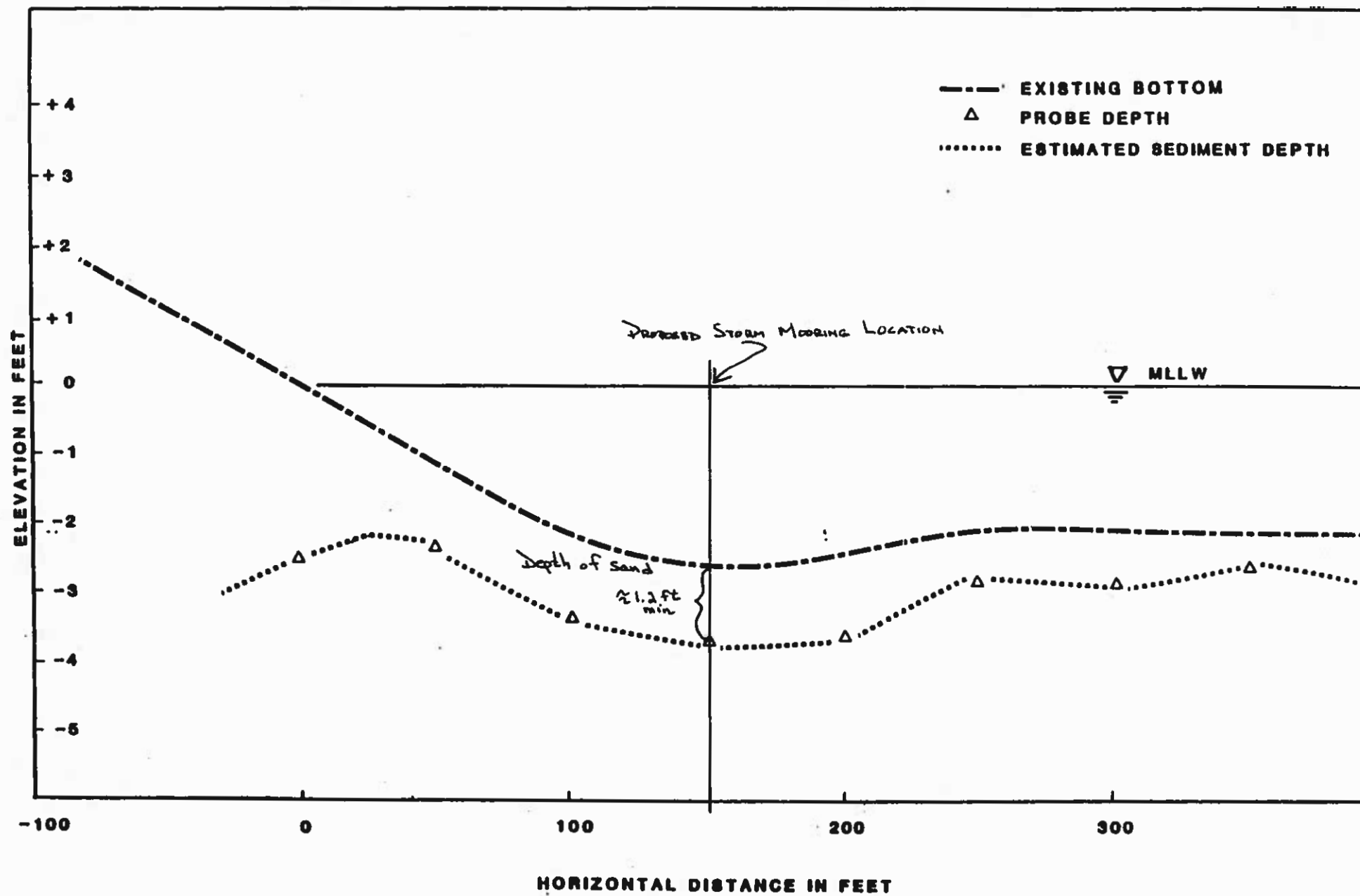


Figure 12. Nearshore sediment profile No. 13 at Site 3.

patches. Fishes are either isolated to small rock clusters like damselfish or migrating forms like mullet, small jacks and goatfish.

The nearshore environment is extremely similar to the mid-bay region with a slight increase in turbidity related to freshwater intrusion from the water lens.

#### C. Substrate Type

Two distinct substrate types exist at the various mooring sites. Sites 1 and 2 have similar substrate types comprised mostly of loose unconsolidated sand with coral rubble. A more homogeneous substrate of a thin unconsolidated sand layer and some coral rubble on hard pavement exists in the offshore zone where the existing anchors are placed. Substrate type at site 3 is a homogenous zone of beach deposits. Live coral does not exist in the vicinity where these moorings exist or are planned.

#### D. Proximity to Live Coral

None of the proposed mooring sites or the existing mooring are located near to areas of live coral and no corals were observed in the vicinity of each mooring.

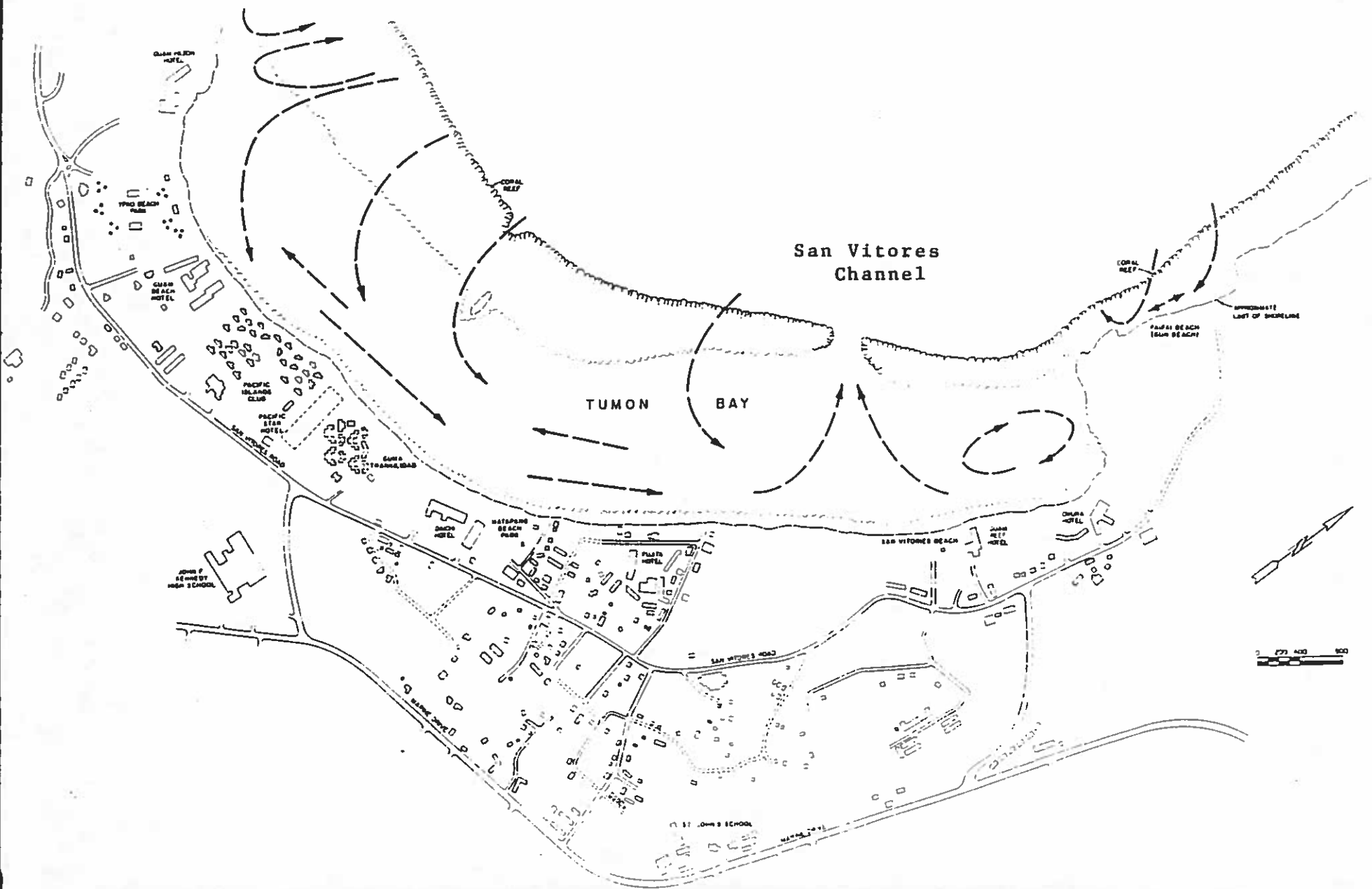
#### E. Currents, Water Exchange and Flushing

Water quality inside Tumon Bay is partially dependent on the water circulation in and around the bay. Of particular importance is the seawater exchange rate with the ocean. Seawater exchange is primarily caused by the tide, however wave and wind induced currents are also important in the exchange process.

Currents in Tumon Bay are well documented in a number of different studies done over the years. However, past water circulation studies were all done as a minor part of a larger study and data do not represent a continuous cycle over a long period of time. It is fortunate that each of the studies covers currents at a different period in the year giving some indication of seasonal variations. Figure 13 is a generalized description of currents in Tumon Bay.

Currents were evaluated most recently by PBEC Inc. (1987) as part of a plan to dredge nearshore portions of Tumon Bay. Results of these current studies reflect data reported by Jones and Randall (1972), Randall and Jones (1973) and the U.S. Navy (1974). The prevailing longshore current is from the south to the north along the shoreline and out in the middle of the bay during storm conditions. There appear to be some definite reversals in the southern half of the bay on a flood tide with water moving toward the south. This water is met by a greater volume of water flowing over the reef driven by waves which force currents inside the lagoon to eddy in the vicinity of the Hilton Hotel.

Water movement in the extreme northern part of the bay is considerably different than movement in the central part with more complicated reversals and eddying. The steep limestone wall at this point stops all water movement further to the north creating the confusion and eddying. Water moves out of the bay through the San Vitores channel on both ebb and flood tides. The only difference in water movement is a generally slower velocity during a flood tide.



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Currents were also measured during storm conditions. We were fortunate to obtain data related to a very large storm that did not affect Guam with heavy winds or rains but did bring very large waves to the west coast for 12 continuous days in October 1987. This storm represents the heaviest surf conditions on the west coast in recent history which allowed us to study the effects of greater water volume and surf in the Tumon Bay lagoon.

Fewer data points were measured during storm conditions because we were not sure just how long the storm conditions would last and also because of the great difficulty of obtaining data in the field under these conditions. Results indicate no substantial difference in the direction of water movement between normal and storm conditions. However, the velocity of water increased significantly with storm conditions (often twice the velocity). The volume of water on the reef-flat was significantly greater than normal conditions, driven with greater force by the huge waves moving onto the reef-flat and across the shallow lagoon.

Water exchange, flushing and turnover rate in the bay is good, particularly in the southern and central sectors of the bay. The exchange of water over the reef is unobstructed throughout the bay with the exception of the extreme north and south ends where steep limestone cliffs prohibit lateral water movement. A large volume of water is able to move in over the reef, driven by waves and winds, and exit out over the reef through the natural channel at San Vitores over different tidal cycles

primarily because of the shallowness of the bay. Predominant current direction (south to north) ensures a continuous flow of water, forcing reasonable turnover and exchange of water.

Clayshulte and Zolan (1976) investigated the volume of water transported over a short section of beachfront in Tumon Bay and discovered that it ranged from 3 to 16 cubic meters per second. Jones and Randall (1972) suggested that poor water exchange and flushing in front of the Okura Hotel was the result of complex current patterns. It is also likely that the circulation and flushing ability of water in this region of the bay suffers because circulation is blocked on the north side from eddying. Water circulation in the southern end of the bay (in front of the Hilton Hotel) is not so completely blocked since the shoreline angles obliquely away from the bay rather than directly offshore as it does in the north.

A measure of the exchange rate for a bay is the residence time, which is defined as the time it takes for the center of a water mass discharged in the bay to be dispersed to the ocean. The analysis assumes the mass is uniformly mixed in the bay initially and dispersion is caused solely from dilution with sea water that enters the bay during flood tide. Since part of the volume of water that enters the bay during flood tide is made up of water that left the bay on previous ebbs, a flood tide exchange ratio is a part of the analysis. The flood tide exchange ratio is defined as the ratio of new ocean water to total volume of water that enters the bay during flood tide. Similarly, part of the water that leaves the bay during

ebb tide is made up of water that entered the bay on previous floods, so an ebb exchange ratio is also a part of the analysis. No data have been collected to estimate the ebb and flood exchange ratios for Tumon Bay. For purposes of analysis, a value of 70 percent was used to represent both exchange ratios. Based on the above assumptions, Sea Engineering Inc. (1987) estimated the residence time for Tumon Bay to be 2.6 days for an average tidal range. This estimate is slightly less than the minimum determined by Marsh et. al. (1981) who determined the residence time between 3 and 6 days.

#### F. Water Quality

Water quality data from Tumon Bay are not extensive. Zolan et al. (1978) analyzed groundwater seepage into Tumon bay. Clayshulte and Zolan (1976) investigated the environmental impact of an illegal storm drain at the Continental Hotel (now Pacific Islands Club Hotel). Marsh (1977) studied nutrient concentrations related to phytoplankton blooms in Tumon Bay. These and a few other miscellaneous studies give some indication of water quality in Tumon Bay. The GEPA collects water samples as a continuing part of their water quality monitoring strategy. However, the only parameter analyzed for by GEPA is bacteriological contamination (total and fecal coliform bacteria). GEPA's primary concern regarding water quality in Tumon Bay is in response to environmental impacts associated with storm drains emptying stormwater into the nearshore areas of the lagoon primarily near populated recreation beaches.

Salinity, although not well documented in Tumon Bay, appears to be within standard levels for seawater (31-34 ppt). Clayshulte and Zolan (1976) obtained this range and a mean value of 32 ppt in Tumon Bay. These data indicate that salinity ranges between 31 and 32 ppt within 5 to 10m of the shoreline and increases to between 32 and 34 ppt 10 to 50m from the shoreline. Mixing of freshwater seepage along the shoreline lowers salinity in the nearshore environment where limited marine life exists. They determined that the discharge of freshwater from storm drains into the bay mixes sufficiently with lagoon water and does not stress the biology of the bay.

Groundwater seepage into Tumon bay occurs all along the coastline (particularly heavy in the northern region) and was measured to be approximately 1.5 cubic feet per second (cfs) over a 150 ft section of beach near Gognga Beach (Emery, 1962). Emery observed velocities greater than 1 ft/sec and noted that the deep rills at Gognga Beach and other locations along Tumon Bay are due to escape of fresh water during low tides. Zolan et. al. (1978) identified at least five major sites of groundwater seepage in Tumon Bay along Ypao, Matapang and Gognga Beaches.

Submarine seepage of groundwater is common throughout Tumon Bay and is thought to be the primary reason why nutrient levels are so high and phosphorus levels so low in water samples collected from the bay. Water samples collected by James Marsh of the UOG Marine Laboratory contained a mean nitrate concentration of 0.008 mg/l and a reactive phosphorus

concentration of approximately 0.02 mg/l. Marsh (1977) noted that during phytoplankton blooms, the mean nitrate level of Tumon Bay seawater decreased to nearly 0.004 mg/l while the mean phosphorus level increased to approximately 0.06 mg/l. Marsh goes on to theorize that the increase in phosphorus concentrations in the early part of the rainy season, combined with the slow rate of flushing in the northern sector of Tumon Bay, may be responsible for the periodic dinoflagellate bloom known to occur in the lagoon. Although these blooms occur nearly every year, they have never been severe enough to cause fish kills or create health hazards to humans.

Clayshulte and Zolan (1976) reported high concentrations of both phosphorus (0.128-0.750 mg/l) and nitrates (0.212-0.238 mg/l) in water samples collected near storm drains. Further out in the bay, concentrations ranged from 0.003-0.053 mg/l for phosphorus and 0.011-0.080 mg/l for nitrates. They indicate that the high nitrate concentration in groundwater seepage conceals the effect of nitrate from storm drains. Another finding of this study is that storm drains are sources of bacterial and heavy metal contaminants in Tumon Bay. Another source of bacterial contamination in the bay is from heavy human use. The exact source of heavy metals is not known but thought to be petroleum products coming from automobiles and trucks and transported to the bay in runoff water from nearby paved surfaces (roads and parking lots).

Turbidity in Tumon Bay has been measured in only a few studies. Clayshulte and Zolan (1976) found turbidity levels consistently less than 1 NTU in the vicinity of their study site (Pacific Islands Club). Turbidity of

stormwater runoff ranged between 2 and 18 NTU, however this was confined in water close to shore. PBEC Inc. (1987) conducted environmental monitoring water quality analysis for turbidity associated with the dredging of a swimming hole in front of the Pacific Star Hotel. Turbidity values within 100m of the silt curtains ranged from 0.14 to 1.22 NTU over a period of three months. The dredge site was encircled with a silt curtain protecting the surrounding area from higher turbidity levels.

#### G. Development and Use of Tumon Bay

Tumon Bay is the center of tourism on Guam and, for planning purposes, has recently been rezoned as Hotel/Resort. More than 90 percent of all hotels on Guam are located within the boundaries of Tumon Bay including all the major hotels. There are also numerous tourist-related commercial establishments which can be grouped in the following categories: gift shops, restaurants, nightclubs, markets and recreational activities.

For the past two years Tumon Bay has been undergoing major infrastructure development to keep up with an increasing tourist population. Major road construction, sewer and water main enlargement and stormwater runoff protection are the major elements to infrastructure improvements in the Tumon Bay area.

Residential housing development in the Tumon Bay area is still significant. Single-family houses exist in the area and more continue to be built. More importantly, multi-unit apartment and condominium developments are being built at an increasing rate along Tumon Bay.

Human use of the lagoon is quite varied. Fishermen continue to use throw and surround nets in the bay, wind surfers utilize the extreme northern and southern areas, numerous individuals can be seen out on the water with various forms of water craft and swimmers are always present. Snorkelers and spearfishermen use the bay on a continuing basis. The area is also used by a two Sunset Cruise boats and Hobie Cat sailboats as well.

#### H. Archaeological/Historical

All mooring structures proposed in this plan are to be placed in the sand so they will not be a hinderance underwater. Since they are not located on land, no archaeological/historical resources are expected to be affected by the moorings. Contact with the Guam Historical Preservation Office indicates no archaeological/historical resources exist in the vicinity of the proposed mooring sites.

### **IV. Environmental Impacts**

#### A. Positive

Placement of permanent mooring systems within Tumon Bay will reduce the amount of damage to delicate resources within the bay by indiscriminate anchor dropping. These moorings will define permanent mooring locations in areas away from coral patches and in areas safely away from tourist foot traffic. Permanent moorings will also give the owner/operator, Coral Reef Water Tours/Sunset Cruises, the peace of mind that they have a place to moor safely in the event of large storms. The

owners can be assured that their investment and business potential is protected against possible damage from typhoons. Similarly, the environment and other property will be protected from damage resulting from a poorly moored vessel breaking away during a storm.

#### **B. Negative**

Very slight negative environmental impacts are associated with this project. The only negative impact will be felt in terms of minor damage to marine flora and fauna during placement of the mooring systems. Each mooring block (anchor) will effectively replace the flora and fauna on or under the substrate. However, the area altered for the anchors is minor: (small blocks, 3 each,  $6y^3$  total); large blocks, 2 each,  $9y^3$  total) and therefore the impact area is minor as well. This assumes disturbing an area twice the size of the concrete block to be buried. This is particularly true since these blocks will be placed in areas where flora or fauna growth is negligible. Access to the offshore mooring sites in front of the Sea Horse Restaurant is over a uniform sand zone. Therefore there will be no damage to marine life in the area. Since the digging of holes will be done at low or minus tides, siltation will be minimal and cause no adverse impacts.

### **V. Alternative**

#### **A. No Action**

The alternative of no action would mean that the condition would remain as it is now and would effectively mean no improvement in the situation. One mooring system already exists and is considered illegal. No

action would cause this system to remain illegal and would therefore require removal. This would leave the owner without his only storm mooring system and would jeopardize his entire operation in the event of a large storm or typhoon. In this case, tourist plans would be jeopardized especially for those who have pre-purchased tours on these vessels. It would also adversely effect all other tourists who might purchase tickets for the vessel on an individual basis.

For these reasons, the alternative of no action is not considered a viable one and is rejected.

#### **B. Plan Modification**

Several plans have been studied regarding this proposal for permanent mooring systems in Tumon Bay. Modifications to the original plan have occurred in the following areas:

1. Number of moorings
2. Location of moorings
3. Size of mooring anchors
4. Design of mooring systems

The extent of these modifications is represented herein as the best possible plan.

#### **C. Different site**

Different sites, as defined here, means an operational site other than Tumon Bay. Many other sites were evaluated during the earliest phases of developing the Sunset Cruises concept as a part of Coral Reef Water Tours Inc. Alternate sites included Apra Harbor and Cocos Lagoon.

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A cost evaluation of operation at each of the sites revealed significant savings in time, logistics and money if the operation were centered in Tumon Bay. Besides saving the owner considerable money and time in terms of capital outlay for bus equipment and logistics support to sites other than Tumon Bay, is the savings which could be passed to the client for a more central operation site. For these reasons, Tumon Bay was chosen as the best and logical operational site. Initially, two small vessels were built to handle tourists in the shallow waters of the bay. One of these was recently hauled out and a larger vessel was brought in to handle the increase in tourism. Other sites were then written off as impractical.

#### **VI. Recommendations**

- A. Limit all work for digging holes and mooring anchor placement to periods of low or minus tides.
- B. Bury the concrete mooring blocks beneath the sand so that they do not create a hazard to pedestrian beach traffic or water craft.
- C. Spread around excess spoil material from each hole on top of buried concrete blocks.
- D. Minimize use of heavy equipment (backhoe) on the beach and out in the lagoon.

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