LIMITED CURRENT AND BIOLOGICAL STUDY IN THE TUANMOKOT CHANNEL, PONAPE

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INTRODUCTION

Background

On April 4, 1974, Deputy High Commissioner Peter T. Coleman of the Trust Territory of the Pacific Islands wrote to Governor Carlos C. Camacho of Guam requesting the assistance of personnel from the University of Guam Marine Laboratory to conduct a limited current and biological study in Tuanmokot Channel, Ponape, where a sewer outfall is presently being constructed. The letter was forwarded to President Antonio C. Yamashita of the University of Guam who in turn sought our comments on the project. Since the Marine Laboratory staff was in agreement that this study should be carried out, our comments were relayed to the Governor who responded favorably to the Deputy High Commissioner's request.

On May 28, Dr. Masao Kumangai, Chairman of the Trust Territory Environmental Protection Board (TTEPB) requested the University of Guam to submit a proposal and budget for the proposed study. On June 7, the Director of the Marine Laboratory submitted a proposal and budget which was accepted by the TTEPB on July 9. The formal contract (TT Contract No. 175-5) between the Government of the Trust Territory of the Pacific Islands and the Government of Guam was finalized and signed on August 9.

Two days later on Aug. 11, a four-member team from the University of Guam Marine Laboratory flew to Ponape and spent the next five days (Aug. 12-16) carrying out the study as per contract agreement.

Scope of Work

1. What effect, if any, the anticipated discharge of secondary

effluent will have upon the ecological conditions of Tuanmokot Channel.

2. Define the present ecological condition of Tuanmokot Channel.

3. Recommend most economical steps to improve ecological conditions in the channel, if those conditions now need improvement, or if it may be anticipated that ecological conditions will be degraded by virtue of the anticipated discharge from the waste-water treatment plant.

Personnel

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GENERAL DESCRIPTION

General Setting

Ponape consists of a high volcanic island surrounded by an outer barrier reef which is interrupted at intervals by deep passes (Fig. 1). The main island is drained by a radial pattern of rivers and streams which empty into the lagoon. In the lagoon between the barrier reef and the main island a complex of both high rocky islands and low mangrove islands are found. Fringing reefs and shallow shelves border the main island and most of the smaller lagoon islands. Mangroves border most of the shoreline along both the main island and smaller lagoon islands. In the lagoon itself, numerous patch reefs reach the surface. These patch reefs range from small isolated pinnacles, a few tens of meters across, to long ridges and intricately curved and branched reefs, several kilometers or more in length, which sometimes enclose both shallow and deep secondary lagoons.

A complex variety of marine habitats are found on the seaward and lagoon barrier reef terraces and slopes, reef flats, deep barrier reef passes, fringing island reefs, patch reefs, coral knolls and banks, deep lagoon basins, shallow lagoon shelves, enclosed secondary lagoons, river estuaries and mangrove swamps.

Study Site

The outfall site is located on a small peninsula on the northern end of Ponape Island (Fig. 2). The village of Kolonia occupies most of the peninsula and is the administrative center for the Ponape District of the Trust Territory. Kolonia is separated from a high peninsula to the east by a shallow bay (here called East Bay), the head of which consists of the Tawenjokola River estuary. A shallow channel trends in a northerly direction from this bay, between the east end of Takatik Island and the high peninsula into the main part of the northern barrier reef lagoon and the deep Ponape Pass.

A shallow reef flat and shelf, generally less than three meters deep, separates Kolonia from Takatik Island to the north. Takatik Island is a low mangrove island and is the site of the Ponape airport. The island is now connected to Kolonia by an earth and rock filled causeway.

A long narrow channel (Tuanmokot Channel) separates Kolonia from Jokaj (Sokehs) Island to the west. To the south this channel is connected to the main part of the western barrier reef lagoon by the narrow Mokota Channel. This channel is navigable by small craft only at high tide and is lined by dense mangrove growth along its sides. The channel on the west side of Kolonia is considerably deeper than the bay on the east side. Tuanmokot Channel trends in a northern direction between Jokaj and Takatik Islands toward the northern barrier reef lagoon and the deep Jokaj Pass. The Commercial Port facilities are located along the west side of the channel near Takatik Island. It is in this channel that the proposed outfall is to be constructed. This effluent is to have secondary treatment and have a capacity of 100,000 gpd [Hawaii Architects and Engineers, Inc.(1968)].

The shoreline along both sides of Tuanmokot Channel is bordered by extensive mangrove growth except for regions where occasional clearings for houses and boat passages occur. Mangrove islets are located on some of the larger patch reefs along the length of the channel, particularly on the eastern shoreline. Considerable disturbance has occurred along the northeast part of the channel by dredging and construction of the Commercial Part facilities and the construction of the causeway between Takatik Island and Kolonia. At present the shallow reef flat area on the west side of the causeway is being utilized as a solid waste landfill. The new land being created will apparently be utilized for future commercial development.

Water circulation and previous current patterns between Tuanmokot Channel and East Bay have been greatly reduced by the construction of the causeway. The only connection between the two bodies of water at the present time is by a single culvert, about 8 meters wide, that is located at the south end of the causeway. Small craft use the culvert to pass from one side of Kolonia to the other at high tide.

Residential areas are scattered along the shoreline along both sides of the channel with the greatest density being located near the outfall site itself. "Benjos" built out over the mangrove flats are a common occurrence along the shoreline. At the south end, where the bay narrows into the Mokota Channel a causeway and bridge connects Kolonia with Jokaj Island. As with the causeway and culvert connecting Takatik Island with Kolonia, the causeway and bridge restricts the flow of water through the Mokota Channel.

Dragline dredging operations are being conducted along the southern end of the bay eastward from the causeway bridge. Lagoon sediments are being dredged from a narrow reef flat that fringes this end of the channel. The sediments are mostly of bioclastic origin with some volcanic mud and gravel intermixed. A conspicuous feature of the sediments are the presence of numerous large fossil Tridacna gigas valves. This large bivalve is no longer found living on Ponape but judging from the number being dredged from the reef flat and lagoon sediments they were once very abundant. The dredging operations produces considerable dredge spoil which appeared to be contained more or less to the southern end of the bay. When strong tidal currents are flowing westward in Mokota Channel much of the dredge spoil is probably carried away from the bay to the western lagoon.

METHODOLOGY

Current Study

Two 24-hr current studies were carried out on August 13-14 and August 15-16 to obtain some information on the general patterns of water circulation in the study area. The results from these studies would provide information on what areas might be affected by the anticipated discharge of secondary effluent.

The first order of business was to locate the exact site of the anticipated discharge. Based on the blue prints of the outfall construction plans and information obtained from the contracting engineer from Hanil Development Company, the site of the effluent release was shown to lie in a direction of $110^{o}24'$ and extend 840 feet (256 m) from shore. Since the contractors had already constructed part (77m long) of the jetty for the laying of the sewer pipes, the remaining distance (179 m) was measured off and a buoy was anchored over the site in 30 ft. (9.4 m) of water.

Pairs of drogues, 1 m and 5 m deep, were released from this marker (buoy) and the positions of the drogues were recorded each hour. This method is similar to those employed by Jones, Randall and Strong (1974) on Guam. When the drogues seemed to be heading towards the reef flat or were grounded, they were returned to the buoy and released again. The direction and speed of 14 drogue casts were obtained during each of the 24-hr studies. Wind direction and speed were also recorded each hour since the 1 m drogue can be greatly influenced by this parameter.

Biological Study

The present ecological and biological conditions of the study site were defined by recording and quantifying the dominant corals, fishes and marine plants along six transects. The selection of the transect sites (Fig. 3) was based on information obtained earlier on water circulation. Thus, the transects were located along anticipated construction zones or in the pathway of the anticipated sewer discharge. In addition, the biological study was focused on the shallow reef platforms and reef margin (Fig. 4) because these would be the areas most affected by the effluent.

Transect 1 (Sewer Pipeline Route). This transect (177 m) was run along the proposed outfall route. The primary purpose of describing the biological components here was to provide baseline information prior to the laying of the sewer lines.

Transect 2 (North Patch Reef). This transect (60 m) located about 100 m beyond the proposed outfall line, was run between two mangrove (Rhizophora) stands on the upper patch reef surface which is exposed during extreme low tides.

Transect 3 (North of Jetty). This transect (100 m) was laid in a meandering manner as to alternately cross the reef flat margin and the lagoon slope five or six times each.

Transect 4 (South of Jetty). This transect (100 m) was run along the reef margin.

Transect 5 (North of Jetty). This transect (180 m) was run perpendicular to the shoreline on the reef platform which is partly exposed during low tides.

Transect 6 (Southwest Patch Reef). Observations were made on various organisms inhabiting this depauperate reef top which is partly exposed during low tides.

Corals

The methodology used for the coral analysis was the same point-centered technique in a previous environmental study (Jones, Randall, and Tsuda, 1974). A series of points, 10 m apart, were selected from the transect line. The area around each transect point was divided into four equal quadrants. The coral nearest the transect point in each quadrant was located and its specific name, diameter or basal area, and center of the corallum point to transect point distance was recorded.

Coral density, percentage of substratum coverage by living corals, and frequency of occurrence were then determined from the above data. An overall Importance Value was assigned to each species by summing the relative values of each of these parameters. A more detailed analysis of the overall species diversity was obtained by making a twenty minute search along the general area on both sides of the transect.

Fishes

An underwater tape recorder (Jones and Chase,MS) was used to visually quantify the fishes in terms of species density, the number of fish seen per square meter, and species frequency. The ratio of the number of individuals to the number of species on a transect was then calculated. Relative values for density and frequency were computed by totaling all values of species density or species frequency for one transect. Then, each individual species density or species frequency value was divided by this total and multiplied by 100 to obtain a percentage which relates all densities or frequencies from a transect.

Transect data tend to be biased toward smaller, territorial fishes which remain on the transect in the presence of a SCUBA diver. A small percentage of fishes are cryptic and/or nocturnal, and these were not actively sought due to the poor visibility of the water.

Marine Plants

The same technique used in a previous study (Jones, Randall, and Tsuda, 1974) was used. The algal community was analyzed by a point method designed to incorporate small quadrats (25 cm X 25 cm) placed at 5 or 10 m intervals on a measured transect line. The quadrat frame was divided into a grid of 25 squares, each 5 cm X 5 cm, providing 16 interior "points" where the grid lines intersected. Each species was recorded at every "point" at which it occurred. If no alga was found under any of the "points", then whatever was present, e.g., sand, dead coral, live coral, was recorded.

From these data, values for relative abundance and relative frequency were calculated for each species on each of the transects. In addition, the percent of algal cover in relationship to the amount of dead coral, live coral, and sand in each area was calculated by considering every item recorded at all "points".

Bacteria

Bacteriological samples were taken and processed for fecal and total coliform by W. A. Brewer and E. Hellan to provide baseline information prior to the discharge of secondary effluent. Since sewer discharge is primarily a freshwater solution which mixes with the surrounding seawater as it rises to the surface (Jones and Randall, 1971),the samples were mainly obtained from the surface water.

Samples along a vertical profile were also taken to obtain some idea of the stratification of coliform at the surface, midwater, and bottom. Salinity, temperature, and oxygen values were also recorded along with the vertical coliform samples.to provide possible causal parameters if coliform counts differed considerably at the different depths.

Membrane filter method as per Standard Procedure was used throughout. Total coliforms were cultured on DIFCO - M - Endo media at 35' I 0.5' C; fecal coliforms were cultured on DIFCO M-FC media at 44.5' I 0.5' C.

RESULTS AND DISCUSSION

Current Description

Austin, Smith and Associates, Inc. (1968) conducted preliminary studies on tidal action in the study area. This is of interest since the causeway connecting Takatik Island and Kolonia was not present at this time. Based on three separate observations between February 26, 1968 and March 1, 1968, they report the following:

> "On rising tides, water flows southward between Kolonia and Sokehs Island through the Tuanmokot Channel until the flow meets the flooding tide from the southwestern side of Sokehs Island. On the ebbing tide the flow reverses itself and flows northward west of Takatik Island. Any floating material is slowly driven to the mangrove areas along the eastern shoreline of Sokehs Island by the northeasterly winds."

With the construction of the causeway, there are only three confined routes that a body of water can take to reach the outfall site. The primary route is through Jokaj Passage which is north of the outfall area. The other two routes are through narrow culverts - an east culvert leading to East Bay and a southwest culvert leading to Mokota Channel.

Tidal fluctuation is even more a primary causal factor influencing the direction of currents in the Tuanmokot Channel because of the presence of the causeway. The basic current pattern is still north during ebb tides and southwest during flood tides. Thus, the channel tides fall slightly behind that of Ponape Harbor as seen in Figs. 5 and 8. Since the water exiting through the southwest culvert to Mokota Channel is considerably less than the water entering via Jokaj Passage, water tends to accumulate towards the southwest end of

Tuanmokot Channel. During periods of large tidal fluctuation, more water enters and exits the channel. The two 24-hr current studies clearly show this trend.

On Aug. 13-14 (Fig. 6-7), both the 1 m and 5 m drogues drifted toward a general southwesterly direction. During ebb tides, both drogue casts 12 and 13 headed north. The tidal fluctuation was 2.3 ft. and winds were minimal ranging from 0 to 11.8 mph.

The drogues also followed the general ebbing and flooding tides during the second 24-hr study (Aug. 15-16). In this case, there was a tendency for casts 5-7 and 11-14 to head north during ebb tides (Fig. 9-10). The westerly drift of cast 6 and 7 (1 m drogues) cannot be explained as yet, especially since winds were nil during these hours. The second study definitely showed a greater tendency for the drogues to head north. This is explained by a higher tidal fluctuation (3.5 ft.) on August 15-16 and hence a longer period of ebb tide. Winds during the second 24-hr study were minimal and what little wind that was present blew from the northwest.

Biological Description

Physiography and Coral Distribution

Fringing reef flats border both the Jokaj and Ponape Island sides of the channel. In general, the reef flats are irregular in width and are widest on the Jokaj Island side of the channel. Fringing reefs and mud flats bridge Takatik Island and Kolonia, but much of this region has been disturbed by dredging, causeway and harbor construction, and land-filling activities. These reef flats are the least disturbed near Kolonia at the proposed outfall site.

West and south of the outfall site the reef flats consist of a narrow fringe which borders thick mangrove vegetation along the shoreline. Several old rusting barges rest on this part of the reef flat, one at the edge of the mangroves immediately west of the outfall causeway and another larger one (33 meters long) several hundred meters further west on the lagoon margin of the reef flat. The masts of a sunken boat are exposed at the reef margin south of a large mangrove islet about midway along the east side of the channel. Other shallow reef flat areas are found on the upper surface of the mangrove islets and patch reefs that are scattered along both sides of the channel.

The inner parts of the fringing reef flats bordering the mangroves consist mostly of a noncalcareous mud veneer which overlies an irregular coral rock substrate. For the most part this mud flat is rather barren but locally sea grasses and benthic algae may dominate the surface. A few widely scattered Porites lutea colonies, a few centimeters in diameter, were observed at some locations in this zone, but for the most part it is devoid of coral growth.

The outer half of the fringing reef flat consists of sediments which contain a greater fraction of bioclastic material, but still a considerable part consists of volcanic mud. The bioclastic fraction consists of lime mud, sand, gravel, Halimeda segments, and scattered coral and calcareous algal debris. This outer fringe of sediments thinly veneers an irregular coral rock substrate. Corals are mostly absent but where locally present are small in size, usually under 5-10 centimeters in diameter, and widely scattered. Porites lutea, Pocillopora damicornis, and Montipora divaricata were the most commonly encountered species, but seldom did the substrate coverage ever exceed one percent. Fleshy benthic algae, sea grasses, and a nodular encrusting red alga are more abundant along the outer part of the fringing reef flat platform than on the muddy inner part. A diverse and rather dense sponge population is found in both the inner and outer parts of the fringing reef flats.

Following is a detailed description (Transect 5) of the fringing reef flat platform located immediately to the east of the outfall causeway (Figs. 3 and 4C). Description of the reef flat is given at 20 meter intervals from the shoreline. Width of observation was 10 to 15 meters.

Shoreline (Intertidal Zone)

A mangrove community borders the shoreline. The substrate consists of a soft plastic mud composed mostly of volcanic sediments and organic debris. A few crabs and littorinid snails were observed on the mangrove prop-roots. Mud skipper fish, Periopthalmus koelreuteri, were also common in this region.

Inner Mud Zone

0-20 Meters - Substrate: Volcanic mud, silt, and organic debris; soft plastic consistency, sinking 10-30 cm when walking. Organisms: Surface mostly barren mud with scattered crab and fish burrows, most conspicuous organisms were scattered colonies of dark brown columniform sponges, two small Porites lutea colonies about 2-5 cm dia. were observed on a small boulder; algae consisted of scattered clumps of

Halimeda macroloba and Padina tenuis.

20-40 Meters - Substrate: Substrate here supports a man's weight, consists of less mud and more bioclastic material, small coral boulders intermixed in sediments, Halimeda segments make up most of the bioclastics. Organisms: Widely scattered Porites lutea colonies on coral boulders, most less than 5 cm in dia.; the brown columniform sponge observed from 0-20 m section is more common, small orange hemispherical sponges on some boulders; algae same as 0-20 m section plus some scattered patches of Halimeda opuntia.

Outer Zone

40-60 Meters - Substrate: In general same as above but with an increasing fraction of bioclastic algal fragments and boulders. From 0-40 meters the reef flat is slightly deeper forming a shallow moat about 20 cm deeper than this part of the reef flat. Organisms: Sponges same as above but more abundant with the addition of red encrusting and blue-gray reticulated forms; corals less abundant because of substrate exposure at low-tide; algae same as above with the addition of Caulerpa verticillata which forms a dark green mat less than a cm in height on scattered boulders.

80-100 Meters - Substrate: Same as 60-80 meter section. Organisms: same as 60-80 meter section except that Padina tenuis and Caulerpa verticillata is more abundant; ramose tuffs of Montipora divaricata scattered at outer edge of sector.

100-120 Meters - Substrate: Less mud and more boulder rubble and bioclastic sediments present, less exposure of substrate during low spring tides. Organisms: Few scattered patches of seagrass, Enhalus acoroides; corals more abundant, especially Montipora divaricata and Porites lutea; sponges still abundant with the addition of a large globular black species, some colonies up to 40 cm dia.; algae same as above section.

120-140 Meters - Substrate: Same as 100-120 Meter section, water depth greater, loose boulder rubble more abundant, unconsolidated sand and gravel less abundant. Organisms: Sponges, feather- duster worms, and holothurians about the same density as in 100-120 Meter section; corals in addition to those previously listed are Stylarea punctata, Pocillopora damicornis, and Porites murrayensis; Montipora divaricata forming ramose clumps 20-40 cm across, but widely scattered; algae same as above section.

140-160 Meters - Substrate: Same as in 120-140 Meter section. Organisms: Same as for 120-140 Meter section except that Montipora divaricata is the dominant coral, forming scattered thickets with up to five per cent coverage in local areas; Porites lutea and Porites murrayensis colonies larger, some up to 30 cm dia.

160-180 Meters - Substrate: More coral-algal boulder rubble, areas of bare coral reef rock present, surface more irregular with local relief up to 30 cm. Organisms: Montipora divaricata forming scattered thickets 2-5 meters across, up to 50 per cent substrate coverage in larger thickets; *Porites* species becoming larger, a few colonies up to 50 cm dia.; sponges that were common in the inner mud zone less abundant; Holothurians and feather-duster worms more abundant; coral burrowing bivalves abundant where rocky and coral substrates are present; fleshy benthic algae less abundant but encrusting reddish-green calcareous algae more abundant. Reef flat margin and lagoon encountered at 180 meters.

Reef Flat Margin and Lagoon Slope Zones.

This zone is always covered with water and in terms of corals is relatively rich compared to the reef flat and lagoon floor (See Table 1). Coral Transect 3 was located along the reef flat margin and slope zones of this region (Figs. 3 and 4C). Table 1 gives the density, per cent coverage, and frequency of occurrence for the dominant corals on the reef flat margin and lagoon slope zones at this location. The dominant coral was *Porites lutea* which forms massive flat-topped colonies, up to a meter in diameter, in the reef margin zone and hemispherical colonies of the same size or larger in the lagoon slope zone. The overall per cent of living coral coverage was higher here than for any other region observed at the study site, but diversity was not as high as that found on Transect 4 on the west side of the outfall causeway (Fig. 3 and Tables 1 and 2). This rich reef margin fringe of corals abruptly ends at about 2-6 meters depth where the short lagoon slope grades into the muddy lagoon floor zone (Fig. 4C).

The fringing reef flat zone on the west side of the causeway is slightly deeper than that on the east side but the floral and faunal communities are quite similar (Table 2). Other differences between the two locations are that on the west side there is greater diversity of corals found at the reef margin and lagoon slope zones, the reef flat zone is somewhat narrower, and the lagoon floor is deeper (Figs. 3, 4C and 4D). Transect 4 was run along the reef margin and lagoon slope zones in a manner similar to that described above for Transect 3 (See Fig. 3 for transect location). Although coral diversity is higher along the west side of the outfall causeway the per cent of substrate coverage is lower (Tables 1 and 2). This higher coral diversity could be related to the increased number of habitats found on the west side because of the greater width and depth of the lagoon slope and floor (Figs. 4C and 4D). Both regions are similar though in dominance of massive Porites lutea colonies along the upper reef margin and lagoon slope zones. The deeper part of the lagoon slope has a rather distinct community of corals that were not found on the east side of outfall causeway. Most conspicuous of this distinct coral community was the presence of a large expanse of Goniopora columna colonies which formed a contiguous stretch from a depth of about three meters to the lagoon floor and about 50 meters in length. Also distinct was the presence of large thickets of arborescent Acropora and local regions of dense cespitose clumps of Pocillopora damicornis colonies.

Another region observed but not quantitatively analyzed was located on the west side of the bay at Transect 6. The reef flat, reef margin, and lagoon slope zones at this station are very similar in coral diversity and substrate coverage as that described for Transect 3 (Fig. 4E and Table 2).

On Transect 2 coral diversity, density, and substrate coverage was found to be similar to that found on the fringing reef flat zone at Transects 3 and 4 (see Table 2). The reef margin and lagoon slope zones of this patch reef were not quantitatively analyzed but observations there showed them to be similar in coral diversity, density, and substrate coverage as that found on Transects 3 and 4.

Transect 1 follows along the proposed outfall route (Fig. 3), and the general slope and depth along its length are shown in the vertical profile of Figure 4A. With the exception of a single colony of Pocillopora damicornis, found about 120 meters from the shore, the entire transect was devoid of corals. This was not surprising since much of the transect is located on the soft muddy sediments of the lagoon floor. The rich coral zone found along the reef flat margin and lagoon slope zones (Transects 3 and 4) is interrupted here by a sand and mud zone. The absence of coral growth here is apparently caused by the removal of the coral heads in a band about 10-15 meters wide for a boat channel. The proposed outfall line and causeway follow this rather poorly defined channel across the reef flat, reef flat margin, and lagoon slope zones.

From the end of the causeway to the lagoon slope the substrate consists of a mixture of bioclastic and volcanic sediments, mostly sand and mud with a few boulders intermixed. From the lagoon slope to the end of transect the substrate becomes increasingly muddy. At most places the substrate has a plastic consistency and consists of fine volcanic silt and lime mud. The slightest disturbance of the substrate surface creates great clouds of muddy turbid water and reduces visibility to zero. Normal visibility along the undisturbed bottom was 0.5 to 1.5 meters. Visibility increased somewhat from the bottom of the lagoon floor to the surface, to about 2 meters. At several locations boulders of 5-15 cm in dia. were encountered intermixed in the mud. Attached to the boulders were large bivalves, hydroid colonies, alcyonacion colonies, various encrusting and foliaceous types of bryozoans, sponges of various growth forms, and a single stem of black coral. Other than the occurrence of these occasional patches of boulders and associated fauna, the bottom was rather featureless and devoid of macroscopic organisms. At some places the bottom topography was irregular due to the burrowing and filter-feeding activities of some kind of worm.

Although a complete inventory of the reef coral fauna was not made, 175 species of corals, representing 54 genera, and subgenera were collected or observed during a single visit to a barrier reef pass and lagoon reef margin and slope on the east side of Ponape Island. The lagoon slope was investigated from the upper reef margin down to a depth of 100 feet at the lagoon floor. The barrier reef pass was investigated to a depth of 80 feet. A short 10 minute snorkeling observation of the seaward barrier reef submarine terrace was also made. A more thorough investigation of the various marine habitats of Ponape would most certainly reveal a coral reef fauna comprised of at least 250 or more species and 60 or more genera and subgenera.

Fishes

No complete checklist of Ponape ichthyofauna exists; however, it is probably safe to say there are at least 600 species of fish known to Ponape.

From four transects and concentrated methods of observations, the study site yielded only 45 species from 18 different families,. while about 85 species from 25 families were noted from the barrier reefs in two short dives. This suggests that the area in question is quite impoverished as far as fishes are concerned.

Transects 1 through 4 show a progressive increase in relative density of fishes (Table 3). This is a direct reflection of relief, and coral and algal coverage. Coral and algae provide protection, as well as a food source. Only about a dozen fish species dominated the four transects (Table 4 and 5) and those are mainly from three or four families, the gobies and pomacentrids being the major contributors.

The deeper, mud areas (Tr 1) were almost exclusively inhabited by gobies adapted to burrowing in the substrate. The reef margin, paralleling shore, had the usual gobies in the mud patches, along with a cross-section of reef fishes. The significant point about the species present was that most were juveniles or the smaller reef species such as pomacentrids (damsel fish). There were almost no fish of commercial importance. Snappers, groupers, and surgeon fish were rare, and small.

Observation reveals that the prop roots of the mangroves provide shelter for an immense community of apogonids (cardinal fish), especially Apogon orbicularis and A. fraenatus.

The checklist (Table 6) complied from the outer reefs shows more diversification than the study site. Furthermore, the biomass of the outer reef would so greatly outweigh that of the study site, that there could be no true comparison. The ichthyofauna at the proposed outfall seems to have little to offer either economically or aesthetically.

Marine Plants

The combination of high turbidity and the silty substratum in all transects is the main causal factor for such a depauperate marine flora. Only 16 species (Table 7) of marine plants were found in the channel, patch reef, and fringing reef. Algal cover was highest (Table 8) on the two patch reefs - Transect 2 (65%) and Transect 6 (32%). Halimeda opuntia made up the majority of cover in these areas making up 74% and 70%, respectively. This same species was also dominant on two other transects (4 and 5).

None of the species present here can be termed exotic or rare. One interesting observation was that blue-green algae were not conspicuous in the study area.

Bacteria

The bacterial counts for fecal and total coliform (Table 9) were high only near the residential areas and were for the most part nil in the channel. Three vertical profiles (Table 10) revealed no coliform at the 15 ft. level and only one bottom sample had any counts at all (20 T.C./100 ml). See Fig. 3 for locations of collecting sites.

CONCLUSIONS

The area surrounding the outfall site can be described as a depauperate environment in terms of species diversity mainly due to the excessive siltation present. A total of 46 species of corals, 45 species of fishes, and only 16 species of marine plants was recorded along the six transects. Surprisingly, the reef margin did possess more coral coverage than expected. Algal coverage was fairly high on the reef platform but the high percentage was caused by the abundance of one species, Halimeda opuntia.

It is now possible to provide some concluding remarks on the effect of the anticipated discharge of secondary effluent on the ecological conditions of the channel. The secondary treated effluent will rise to the surface because it is a low density freshwater solution which will mix with the surrounding seawater during its ascent, and diffuse in all directions at the surface. Depending on wind conditions and tidal fluctuations, the main body of the effluent will drift alternately in a north and southwest direction in the channel. The distance the effluent will travel will depend greatly on the tidal range and wind conditions. During neap tides, the effluent will generally stay in the vicinity of the outfall site. However, during spring tides, the effluent may exit past the Commercial Port on its way to Jokaj Passage.

Thus, if the effluent is discharged at secondary treatment level and diffused at the proposed depth of 28 feet, there should be little or no additional adverse effect on the surrounding marine community in Tuanmokot Channel. This situation will exist as long as the sewage treatment plant does not break down and release raw sewage.

We would like to stress that our primary objective during our five-day study in this channel was to answer the environmental questions posed to us by the Trust Territory Environmental Protection Board. This was to predict the effect, if any, of the anticipated discharge of secondary effluent on the ecological conditions of Tuanmokot Channel based on our limited water circulation and biological studies. In terms of the economic considerations, discharge of secondary effluent into the planned area will be most economical especially since the treatment plant is already under construction. Esthetic-wise, the site is a lousy one since four hotels overlook this channel.

It is responsibility of the administrators and the people of Ponape to weigh the advantages and disadvantages of the sewer outfall site in light of the social, economical and environmental parameters.

RECOMMENDATIONS

1. The proposed sewer pipeline route should be followed because it passes through the least developed area in terms of marine life.

2. Multiple-point diffusers as planned should be used to insure adequate mixing of the effluent with the surrounding water.

3. The primary problem in this channel is siltation. Indiscriminate dredging operations in this channel should be controlled. The proposed construction of one more culvert through the causeway which connects Takatik Island with Kolonia will no doubt provide a better flushing action but will not solve the major siltation problem.

4. Further current studies should be continued to obtain information on the speed and direction of the current during other times of year. Also, studies should be continued after the construction of the culvert to monitor the change in water movement.

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Table 1. Living coral density per cent of substratum coverage, and frequency of occurrence. Coral are arranged in order of their Importance Value. See Figure 3 for transect locations.

Transect	Density/m^2	Relative Density	Per Cent Coverage	Relative Per Cent Coverage	Frequency of Occurrence	Relative Frequency of Occurrence	Importance Value
Transect 1							
Only one coral encountered on transect							
Transect 2							
Porites lutea	.1	42.1	.1	41.2	.6	46.1	129.5
Porites australiensis	.1	31.6	.1	29.4	.4	30.8	91.8
Pocillopora damicornis	.1	26.3	.1	29.4	.3	23.1	79.1
Total species 3	Overall density	.3/m^2					
Total genera 2	Overall coverage	.3%					
Transect 3							
Porites lutea	3.7	89.5	41.2	99.0	1.0	76.9	265.4
Montipora divaricata	.2	5.3	.2	>.5	.1	7.7	13.5
Porites australiensis	.1	2.6	.1	.2	.1	7.7	10.5
Platygyra lamellina	.1	2.6	.1	.2	.1	7.7	10.5
Total species 4	Overall density	4.1/m^2					
Total genera	Overall coverage	41.6%					
Transect 4							
Porites lutea	2.6	72.5	23.2	95.8	1.0	52.6	220.9
Hydnophora rigida	.3	10.0	.6	2.5	.3	15.8	28.3
Pocillopora damicornis	.2	5.0	.1	.4	.2	10.5	19.9
Stylocoeniella armata	.2	5.0	<.1	.1	.2	10.5	15.6
Leptastrea purpurea	.2	5.0	.2	.8	.1	5.3	11.1
Goniopora lobata	.1	2.5	.1	.4	.1	5.3	8.2
Total species 5	Overall density	3.6/m					
Total genera 5	Overall coverage	24.2%					
Transects 5 and 6							
No quantitative data, see text for description and Table 2							

Table 2. Checklist of corals collected or observed at Transects 1-6. See Figures 3 and 4 for transect locations and profiles. The relative frequency of occurrence of the corals is given by the following symbols: D=dominant, A=abundant, C=common, O=occasional, and R=rare. Observations were made on the reef flat zone only at Transect 5.

	TRANSECT 1				TRANSECT 2			TRANSECT 3			TRANSECT 4			TRANSECT 5	TRANSECT 6		
	Reef Flat Zone	Reef Margin Zone	Lagoon Slope Zone	Lagoon Floor Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone
<u>Acropora</u> <u>acuminata</u> Verrill							R						O				
<u>Acropora</u> <u>formosa</u> (Dana)					R								O				
<u>Acropora</u> sp. 1									R				O				
<u>Euphyllia</u> <u>glabrescens</u> (Chamisso and Eysenhardt)							R					R	C				
<u>Euphyllia</u> sp. 1												R	C				
<u>Favia</u> <u>pallida</u> (Dana)						R	O		R	R		R	O				R
<u>Favia</u> <u>speciosa</u> (Dana)							O						O				R
<u>Favites</u> <u>flexuosa</u> (Dana)							R										
<u>Fungia</u> <u>fungites</u> (Linnaeus)													O				
<u>Fungia</u> <u>repanda</u> Dana													R				
<u>Goniastrea</u> <u>pectinata</u> (Ehrenberg)							R						R				
<u>Goniastrea</u> <u>retiformis</u> (Lamarck)													R				
<u>Goniopora</u> <u>columna</u> Dana												R	O				
<u>Goniopora</u> <u>lobata</u> Milne-Edwards & Halme												O	A				
<u>Goniopora</u> sp. 1							R						R				
<u>Herpolitha</u> <u>limax</u> (Esper)							R										
<u>Hydnophora</u> <u>rigida</u> (Dana)						R	C					O	C				
<u>Leptastrea</u> <u>bottae</u> Milne-Edwards & Halme								R									
<u>Leptastrea</u> <u>purpurea</u> (Dana)						R	O	R	R	R	O	O	C	O		O	O
<u>Leptastrea</u> <u>transversa</u> (Klunzinger)													R				
<u>Lobophyllia</u> <u>corymbosa</u> (Forskaal)							R						R				
<u>Lobophyllia</u> <u>costata</u> (Dana)							R						R				
<u>Merulina</u> <u>laxa</u> Dana						O	C					O	A				C
<u>Montipora</u> <u>divaricata</u> Brueggemann					O	R		D	C		C	O		O			
<u>Montipora</u> <u>verruosa</u> (Lamarck)							R						R				

Table 2. (continued).

	TRANSECT 1				TRANSECT 2			TRANSECT 3			TRANSECT 4			TRANSECT 5	TRANSECT 6		
	Reef Flat Zone	Reef Margin Zone	Lagoon Slope Zone	Lagoon Floor Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone	Reef Flat Zone	Reef Flat Zone	Reef Flat Margin Zone	Lagoon Slope Zone
Montipora sp. 1 (Ramose)								O									
Pavona (Polyastra) venosa Ehrenberg							O			O			O				R
Platygyra lamellina (Ehrenberg)							O			R			O				R
Platygyra rustica (Dana)							O			O			O				
Platygyra sinensis (Milne-Edwards & Haime)													R				
Pocillopora damicornis (Linnaeus)		R			O	R	R	O	C	R	O	C	R	O	R	O	O
Porites andrewsi Vaughan							R						O				R
Porites australiensis Vaughan						O	C		R	O		R	O				O
Porites cocosensis Wells							O						O				
Porites lobata Dana																	
Porites lutea Milne-Edwards & Haime					D	D	D	A	D	D	D	D	D	O	D	D	D
Porites murrayensis Vaughan						O	C		R	O		R	O				R
Porites (Synaraea) convexa Verrill													R				
Porites (Synaraea) iwayamaensis Eguchi													R				
Porites (Synaraea) horizontalata Hoffmeister							R			R			R				
Porites (Synaraea) monticulosa (Dana)						R	O		R	O		O	C				O
Porites (Synaraea) sp. 1										O			O				
Psammocora contigua Esper					A	O	O			R	O	O	C				O
Psammocora obtusangulata Lamarck						O											
Stylaraea punctata Klunzinger					C			A			C			C	C		
Symphyllia recta (Dana)													R				
TOTAL SPECIES	0	1	0	0	6	12	26	7	9	13	6	15	38	5	3	3	13
TOTAL GENERA	0	1	0	0	6	8	17	5	6	7	6	10	17	5	3	3	8
TOTAL SPECIES FOR TRANSECT		1				30			18			40		5		14	
TOTAL GENERA FOR TRANSECT		1				18			10			18		5		9	
TOTAL SPECIES FOR ALL TRANSECTS 46																	
TOTAL GENERA FOR ALL TRANSECTS 20																	

Table 3. Checklist of fishes at study site, transects on which they were seen, frequencies (F), and relative frequencies (RF); *=fishes that were collected but not seen on a transect.

	TRANSECTS					
FAM/SPP.	1	2	3	4	F	RF
ACANTHURIDAE						
Acanthurus nigrofuscus (Forskal)		+	+	+	.75	4.05
Ctenochaetus striatus (Quoy & Gaimard)			+	+	.50	2.70
Zebrasoma veliferum (Bloch)				+	.25	1.35
APOGONIDAE						
Apogon fraenatus Valenciennes	+				.25	1.35
A. orbicularis		+			.25	1.35
Cheilodipterus quinquelineata (Cuvier & Valenciennes)			+	+	.50	2.70
ATHERINIDAE						
*Pranesus sp.						
BALISTIDAE						
*Balistoides viridescens (Bloch)						
BLENNIIDAE						
Meiacanthus atrodorsalis (Gunther)				+	.25	1.35
CARANGIDAE						
*Carangoides ferdau jordani Nicholso						
CHAETODONTIDAE						
Chaetodon auriga Forskal		+	+	+	.75	4.05
C. bennetti Cuvier				+	.25	1.35
C. ephippium Cuvier				+	.25	1.35
C. falcula Bloch			+	+	.50	2.70

FAM/SPP.	1	2	3	4	F	RF
C. bennetti Cuvier				+	.25	1.35
C. ephippium Cuvier				+	.25	1.35
C. falcula Bloch			+	+	.50	2.70

Table 3. (continued)

FAM/SPP.	TRANSECTS 1	2	3	4	F	RF
C. lunula (Lacepede)			+		.25	1.35
C. trifasciatus (Mungo Park)			+	+	.50	2.70
C. vagabundus Linnaeus			+		.25	1.35
GOBIIDAE						
Acentrogobius belissimus Smith	+	+	+	+	1.00	5.41
Amblygobius albimaculatus (Ruppell)		+			.25	1.35
Bathygobius fuscus (Ruppell)		+		+	.50	2.70
Calleleotris muralis (Cuvier & Valenciennes)	+		+	+	.75	4.05
Obtortiophagus koumansi (Whitely)	+		+		.50	2.70
Oxyurichthys guibei Smith	+	+	+	+	1.00	5.41
*Periopthalmus koelreuteri Eggert						
HOLOCENTRIDAE						
Flammeo sammara (Forskal)			+		.25	1.35
Myripristis murdjan (Forskal)			+		.25	1.35
LABRIDAE						
Halichoeres trimaculatus (Quoy & Gaimard)		+	+	+	.75	4.05
Stethojulis strigiventer (Bennett)			+		.25	1.35
Thalassoma quinquevittata (Lay & Bennett)		+	+		.50	2.70
LUTJANIDAE						
*Lutjanus monostigmus (Cuvier & Valenciennes)						
L. fulvus (Bloch & Schneider)	+		+	+	.75	4.05
MUGILIDAE						
*Chelon vaigiensis (Quoy & Gaimard)						

Table 3. (continued)

FAM/SPP.	TRANSECTS 1	2	3	4	F	RF
MULLIDAE						
Parupeneus barberinus (Lacepede)			+	+	.50	2.70
P. multifasciatus (Quoy & Gaimard)			+		.25	1.35
MURAENIDAE						
Gymnothorax javanicus (Bleeker)			+		.25	1.35
POMACENTRIDAE						
Abudefduf leucozona (Bleeker)		+	+	+	.75	4.05
Chromis caeruleus (Cuvier & Valenciennes)			+	+	.50	2.70
Dascyllus aruanus (Linnaeus)	+	+	+	+	1.00	5.41
Pomacentrus lividus (Bloch & Schneider)		+	+	+	.75	4.05
P. pavo (Bloch)		+	+	+	.75	4.05
SCARIDAE						
Scarus dubius Bennett			+	+	.50	2.75
S. sordidus Forskal			+		.25	1.35
SERRANIDAE						
*Epinephelus caeruleopunctatus (Bloch)						
SIGANIDAE						
Siganus spinus (Linnaeus)		+			.25	1.35
S. vulpinus (Schlegel & Müller)			+	+	.50	2.70

Table 4. Transect Data. N = Number of individuals of a species; d = Density; rd = Relative Density.

SPECIES	1 (179 m^2)			2 (57 m^2)			3 (100 m^2)			4 (100 m^2)			Total of Transects (436 m^2)		
	N	d	rd	N	d	rd	N	d	rd	N	d	rd	N	d	rd
ACANTHURIDAE															
Acanthurus nigrofuscus				1	.018	0.9	4	.04	1.2	4	.04	0.4	9	.021	.62
Ctenochaetus striatus							36	.36	10.5	21	.21	2.1	57	.131	3.88
Zebrasoma veliferum										1	.01	0.1	1	.002	.06
APOGONIDAE															
Apogon fraenatus	5	.028	14.7										5	.012	.36
A. orbicularis				3	.053	2.7							3	.007	.21
Cheilodipterus quinquelineata							11	.11	3.2	10	.10	1.0	21	.048	1.42
BLENNIIDAE															
Meiacanthus atrodorsalis										1	.01	0.1	1	.002	.06
CHAETODONTIDAE															
Chaetodon auriga				1	.018	0.9	5	.05	1.5	3	.03	0.3	9	.021	.62
C. bennetti										3	.03	0.3	3	.007	.21
C. ephippium										1	.01	0.1	1	.002	.06
C. falcula							1	.01	0.3	2	.02	0.2	3	.007	.21
C. lunula							1	.01	0.3				1	.002	.06
C. trifasciatus							12	.12	3.5	3	.03	0.3	15	.034	1.01
C. vagabundus							2	.02	0.6				2	.005	.15
GOBIIDAE															
Acentrogobius belissimus	8	.045	23.6	5	.088	4.4	5	.05	1.5	3	.03	0.3	21	.048	1.42
Amblygobius albimaculatus				4	.070	3.5							4	.009	.27
Bathygobius fuscus				41	.719	36.1				4	.04	0.4	45	.103	3.05
Calleleotris muralis	7	.039	20.4				21	.21	6.1	29	.29	3.0	57	.131	3.88
Obtortiophagus koumansis	3	.017	8.9				2	.02	0.6				5	.012	.36
Oxyurichthys guibei	9	.050	26.2	5	.088	4.4	4	.04	1.2	2	.02	0.2	20	.046	1.36
HOLOCENTERIDAE															
Flammeo sammara							4	.04	1.2				4	.009	.27
Myripristis murdjan							1	.01	0.3				1	.002	.06

Table 4. (continued)

SPECIES	1 (179 m) N	1 (179 m) d	1 (179 m) rd	2 (57 m) N	2 (57 m) d	2 (57 m) rd	3 (100 m) N	3 (100 m) d	3 (100 m) rd	4 (100 m) N	4 (100 m) d	4 (100 m) rd	Total of Transects (436 m) N	Total of Transects (436 m) d	Total of Transects (436 m) rd
LABRIDAE															
<u>Halichoeres trimaculatus</u>				29	.501	25.1	6	.06	1.8	8	.08	0.8	43	.099	2.93
<u>Stethojulis strigiventer</u>							2	.02	0.6				2	.005	.15
<u>Thalassoma quinquevittata</u>				1	.018	0.9	1	.01	0.3				2	.005	.15
LUTJANIDAE															
<u>Lutjanus fulvus</u>	1	.006	3.1				10	.10	2.9	1	.01	0.1	12	.028	.83
MULLIDAE															
<u>Parupeneus barberinus</u>							1	.01	0.3	1	.01	0.1	2	.005	.15
<u>P. multifasciatus</u>							2	.02	0.6				2	.005	.15
MURAENIDAE															
<u>Gymnothorax javanicus</u>							1	.01	0.3				1	.002	.06
POMACENTRIDAE															
<u>Abudefduf leucozona</u>				4	.070	3.5	3	.03	0.9	1	.01	0.1	8	.018	.53
<u>Chromis caeruleus</u>							3	.03	0.9	505	5.05	51.5	508	1.165	34.48
<u>Dascyllus aruanus</u>	1	.006	3.1	15	.263	13.2	5	.05	1.5	349	3.49	35.6	370	.849	25.13
<u>Pomacentrus lividus</u>				2	.035	1.8	23	.23	6.7	19	.19	1.9	44	.101	2.99
<u>P. pavo</u>				2	.035	1.8	173	1.73	50.4	5	.05	0.5	180	.413	12.22
SCARIDAE															
<u>Scarus dubius</u>							1	.01	0.3	1	.01	0.1	2	.005	.15
<u>S. sordidus</u>							1	.01	0.3				1	.002	.06
SIGANIDAE															
<u>Siganus spinus</u>				1	.018	0.9							1	.002	.06
<u>S. vulpinus</u>							2	.02	0.6	4	.04	0.4	6	.014	.41

Table 5. Summary of fish transect data.

ΣN = number of individuals observed on a transect

Tspp = number of species observed on a transect

Transect	Area Sampled	ΣN	Tspp.	Density	Relative Density
1	179m^2	31	7	.17	1.1
2	57m^2	114	14	2.0	13.0
3	100m^2	343	29	3.43	22.3
4	100m^2	981	24	9.81	64.7

Table 6. Checklist of fishes from the barrier reef; C=in the channel; I=inner barrier reef.

	C	I
ACANTHURIDAE		
Acanthurus glaucoparelus Cuvier	+	
Acanthurus lineatus (Linnaeus)	+	
A. nigrofuscus (Forskal)		+
Ctenochaetus striatus (Quoy & Gaimard)	+	+
Naso brevirostris (Cuvier & Valenciennes)	+	
N. literatus (Bloch & Schneider)	+	+
Zebrasoma scopas (Cuvier)	+	
Z. veliferum (Bloch)	+	+
APOGONIDAE		
Cheilodipterus quinquelineata (Cuvier & Valenciennes)		+
AULOSTOMIDAE		
Aulostomus chinensis (Linnaeus)		+
BALISTIDAE		
Balistapus undulatus (Mungo Park)		+
Pseudobalistes flavimarginatus (Ruppell)	+	+
BLENNIIDAE		
Meiacanthus atrodorsalis (Gunther)		+
CANTHIGASTERIDAE		
Canthigaster solandri (Richardson)	+	+
CARANGIDAE		
Caranx melampygus Cuvier & Valenciennes		+
C. sp.	+	
CARCHARHINIDAE		
Carcharhinus menisorrah (Muller & Henle)	+	
CHAETODONTIDAE		
Chaetodon auriga Forskal	+	+
C. bennetti Cuvier	+	+
C. citrinellus Cuvier	+	+
C. ephippium Cuvier	+	
C. falcula Bloch	+	+
C. lunula (Lacepede)		
C. punctato-fasciatus Cuvier & Valenciennes	+	
C. reticulatis Cuvier	+	
C. strigangulus (Gmelin)	+	+
C. trifasciatus Mungo Park	+	+
C. unimaculatus Bloch	+	
C. vagabundus Linnaeus	+	
Forcipiger sp.	+	
Heniochus permutatus Cuvier	+	
H. varius Cuvier	+	
Pygoplites diacanthus (Boddaert)	+	+

Table 6, (continued)

	C	I
CIRRHITIDAE		
Paracirrhites forsteri (Bloch & Schneider)	+	
DASYATIDAE		
Dasyatis sp.		+
HOLOCENTRIDAE		
Myripristis kuntee (Cuvier & Valenciennes)	+	
M. murdjan (Forskal)	+	
KYPHOSIDAE		
Kyphosus cinerascens (Forskal)	+	
LABRIDAE		
Cheilinus arenatus (Cuvier & Valenciennes)		+
C. fasciatus (Bloch)	+	+
C. undulatus Ruppell	+	
Epibulus insidiator (Pallas)		+
Gomphosus varius Lacepede		+
Halichoeres hortulanus (Lacepede)	+	
H. trimaculatus (Quoy & Gaimard)	+	
Labroides bicolor Fowler & Bean	+	
L. dimidiatus (Cuvier & Valenciennes)	+	+
Thalassoma hardwickei (Bennett)	+	+
T. lutescens (Lay & Bennett)		+
LUTJANIDAE		
Caesio sp.	+	
Lethrinus rhodopterus Bleeker	+	+
Lutjanus (vaigiensis) fulvus (Bloch & Schneider)	+	+
L. monostigmus (Cuvier & Valenciennes)	+	
L. sp.	+	
Macolor niger (Forskal)	+	
Scolopsis cancellatus (Cuvier & Valenciennes)	+	
MULLIDAE		
Mulloidichthys samoensis (Gunther)	+	+
Parupeneus barberinus (Lacepede)	+	
P. bifasciatus (Lacepede)	+	
P. multifasciatus (Quoy & Gaimard)		+
MURAENIDAE		
Gymnothorax javanicus (Bleeker)		+
PEMPHERIDAE		
Pempheris oualensis (Cuvier & Valenciennes)	+	
POMACENTRIDAE		
Abudefduf curacao (Bloch)		+
A. leucopomus (Lesson)		+
Amphiprion ephippium Bloch	+	

Table 6. (continued)

	C	I
Chromis caeruleus (Cuvier & Valenciennes)		+
C. hanui Randall & Swerdloff	+	
C. leucurus Gilbert	+	+
C. sp.		+
Dascyllus aruanus (Linnaeus)		+
Pomacentrus lividus (Bloch & Schneider)		+
P. pavo (Bloch)		+
P. tracyei Schultz		+
SCARIDAE		
Chlorurus gibbus (Ruppell)	+	
Scarus dubius Bennett	+	+
S. sordidus Forskal	+	+
assorted scarid spp. (3)	+	+
SERRANIDAE		
Cephalopholis argus Bloch & Schneider	+	+
Epinephelus fuscoguttatus (Forskal)		+
E. sp.		+
Variola louti (Forskal)	+	
SIGANIDAE		
Siganus vulpinis (Schlegel & Muller)	+	+
SPARIDAE		
Monotaxis grandoculis (Forskal)	+	
SYNGNATHIDAE		
Corythoichthys intestinalis (Jordan & Seale)		+
ZANCLIDAE		
Zanclus cornutus (Linnaeus)	+	
	57	49

25 Families

85 Spp.

Table 7. List of marine plants observed in each of the six transect areas.

Species	TRANSECTS 1	2	3	4	5	6
CHLOROPHYTA						
Avrainvillea obscura J. Ag.					X	
Caulerpa verticillata J. Ag.					X	
Halimeda macroloba Decaisne		X	X	X	X	X
Halimeda macrophysa Askenasy		X	X	X		X
Halimeda opuntia (L.) Lamx.		X		X	X	X
Neomeris annulata Dickie		X				
PHAEOPHYTA						
Dictyota bartayresii Lamx.						X
Padina tenuis Bory		X			X	X
RHODOPHYTA						
Actinotrichia fragilis (Forskal) Boerg.				X		
Ceramium sp.				X		
Gracilaria salicornia (Mert.) Grev.		X			X	
Jania capillacea Harvey				X		
Metagoniolithon sp.						X
Polysiphonia sp.				X		
"knobby coralline"			X	X		
SEAGRASS						
Enhalus acoroides (L.F.) Royle	X	X			X	X
Number Species/Trans.	1	7	3	8	7	7

Table 8. Relative abundance (RA) and relative frequency (RF) of benthic plants present in five transect areas. Plants arranged in order of relative abundance values.

Species	RA	RF
Transect 1 - 100% silt (n=17)		
Marine plants absent except for few scattered *Enhalus acoroides* at end of jetty.		
Transect 2 - 65% plant cover, 34% silt, 1% dead coral (n=22)		
Halimeda opuntia	74	55
Gracilaria salicornia	14	19
Padina tenuis	10	16
Halimeda macroloba	2	10
Transect 3 - 5% plant cover, 36% live coral, 22% silt, 21% dead coral, 16% sponge (n=21)		
"knobby coralline	95	67
Halimeda macroloba	5	33
Transect 4 - 18% plant cover, 32% silt, 21% live coral, 19% sponge, 10% dead coral (n=21)		
Halimeda opuntia	30	14
Ceramium sp.	15	7
"knobby coralline"	15	14
Jania capillacea	13	7
Halimeda macrophysa	10	30
Actinotrichia fragilis	6	7
Polysiphonia sp.	6	7
Halimeda macroloba	5	14
Transect 5 - Quantitative study not made on marine plants.		
Transect 6 - 32% plant cover, 64% silt, 4% dead coral (n=11)		
Halimeda opuntia	70	46
Halimeda macroloba	14	14
Padina tenuis	8	8
Dictyota bartayresii	2	8
Halimeda macrophysa	2	8
Enhalus acoroides	2	8
Metagoniolithon sp.	2	

Table 9. Surface fecal and total coliform counts obtained from study area on August 15, 1974 at 0.2 MLLT.

Location	F.C./100 ml	T.C./100 ml
Buoy	0	0
Mangrove 1	0	0
Sandpile	0	100
Mangrove 2	100	0
Mangrove 3	0	0
Barge 1	3000	200
Barge 2	100	0
Kepinle Dock (N side, 200 ft. from shore)	2700	2850

Table 10. Vertical samples of fecal and total coliform counts with accompanying physical data obtained from three sites in Tuanmokot Channel on August 16, 1974.

Location	Depth (feet)	F.C./100 ml	T.C./100 ml	Sal. (°/oo)	Temp. (°C)	O_2 (ppm)
Buoy	0	0	120	30	31.5	5.6
	15	0	0	31	31.5	5.6
	35	0	0	30	32.0	6.1
West of Mangrove 2	0	0	0	28	31.5	3.6
	15	0	0	32	30.7	5.7
	32	0	0	31	30.3	5.8
South of Mangrove 2	0	-	-	28	30.6	4.8
	15	0	0	31	30.2	4.2
	30	0	20	31	29.8	1.9

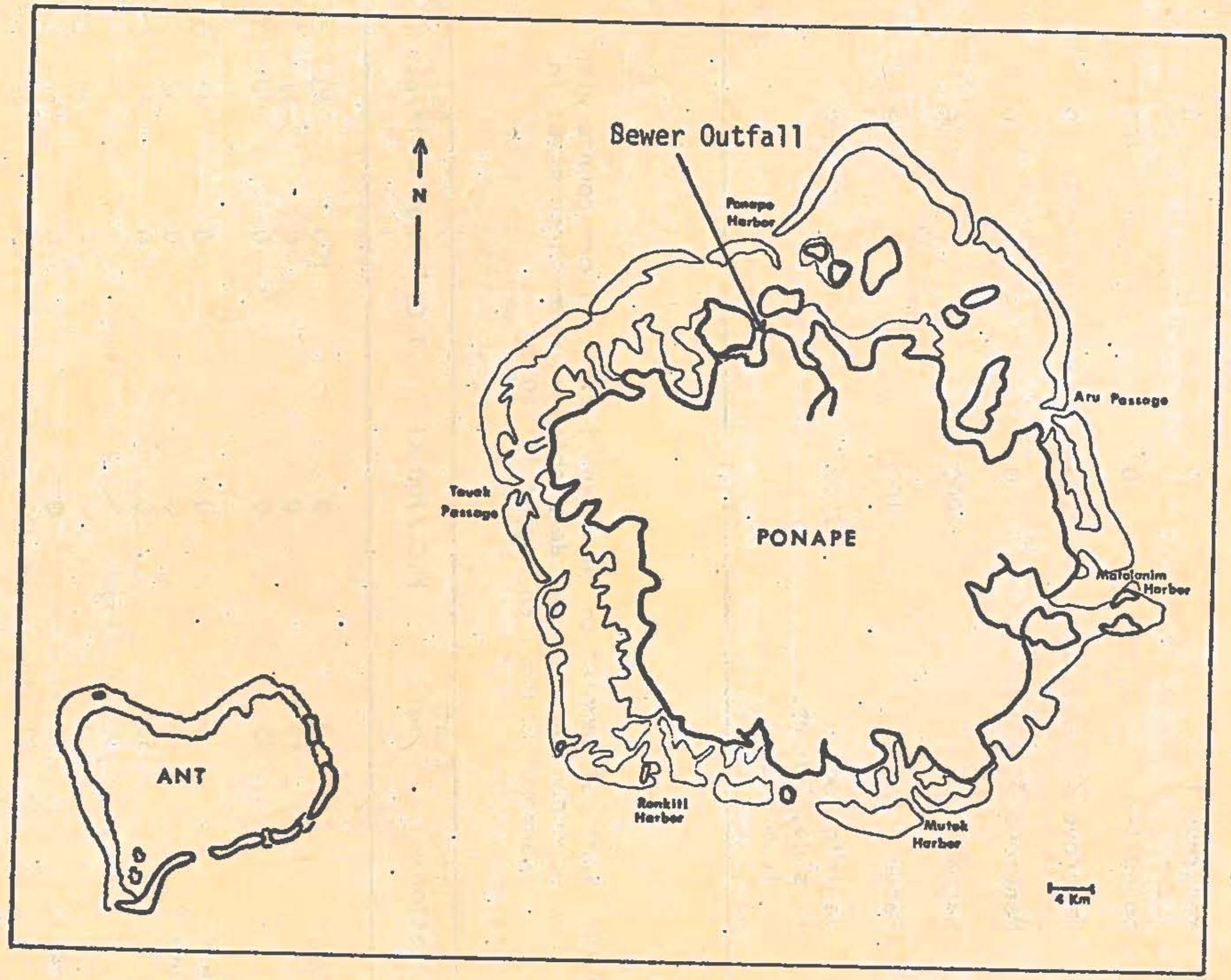


Fig. 1. Map of Ponape showing study area.

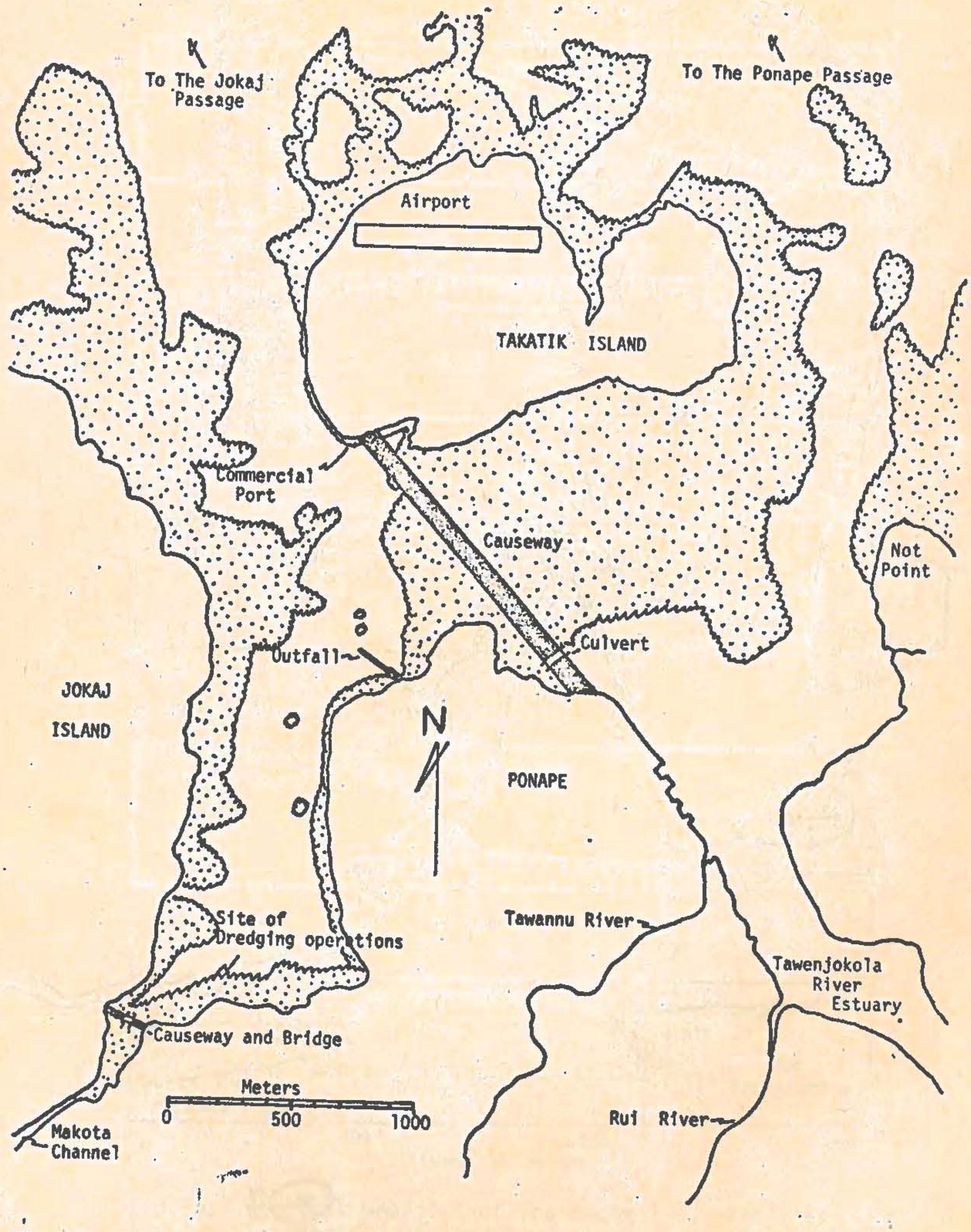


Fig. 2. Map showing the proposed outfall line and fringing reef-flat platforms in the vicinity of the outfall site. Reef-flat platforms are stippled.

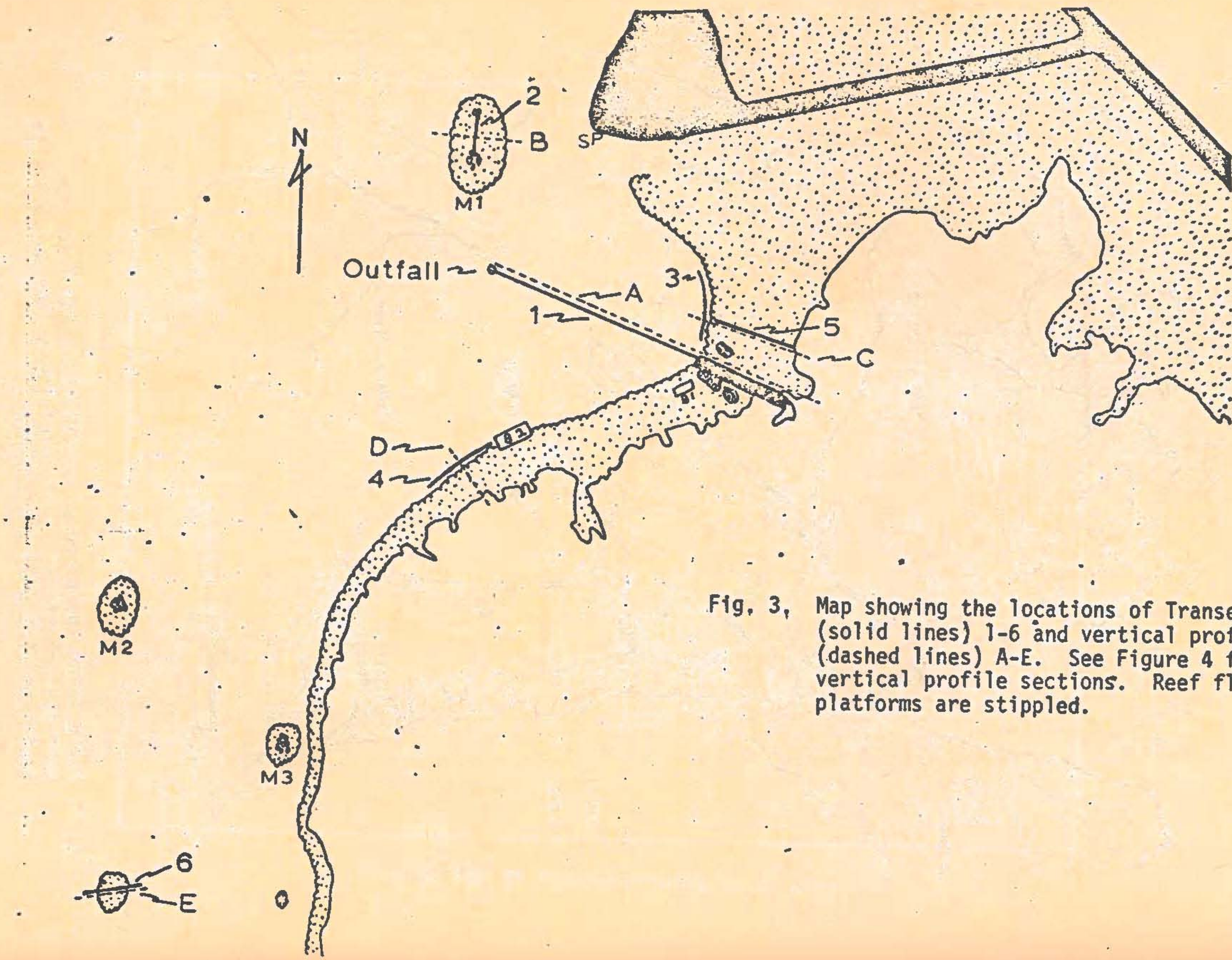


Fig. 3, Map showing the locations of Transects (solid lines) 1-6 and vertical profiles (dashed lines) A-E. See Figure 4 for vertical profile sections. Reef flat platforms are stippled.

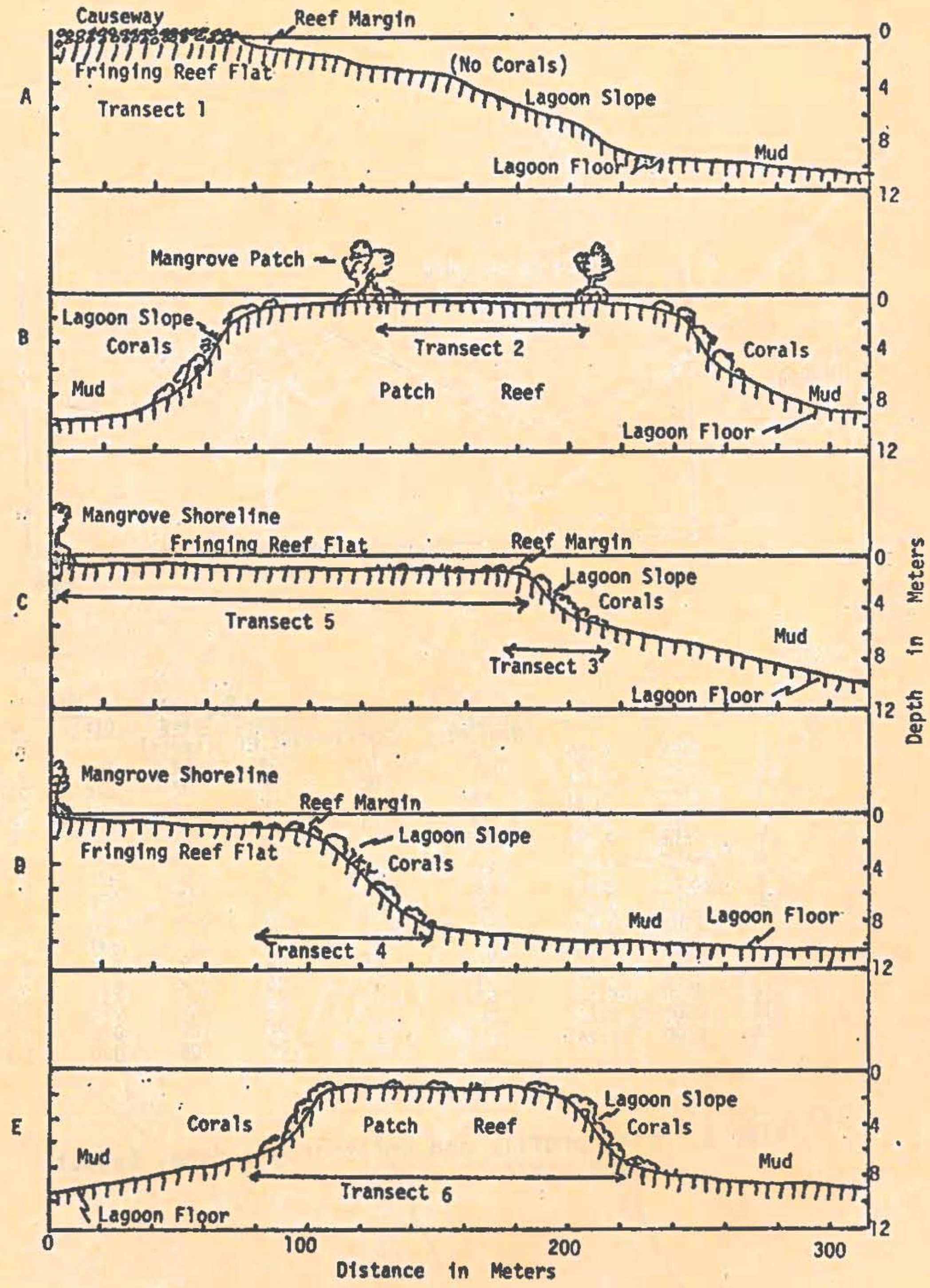
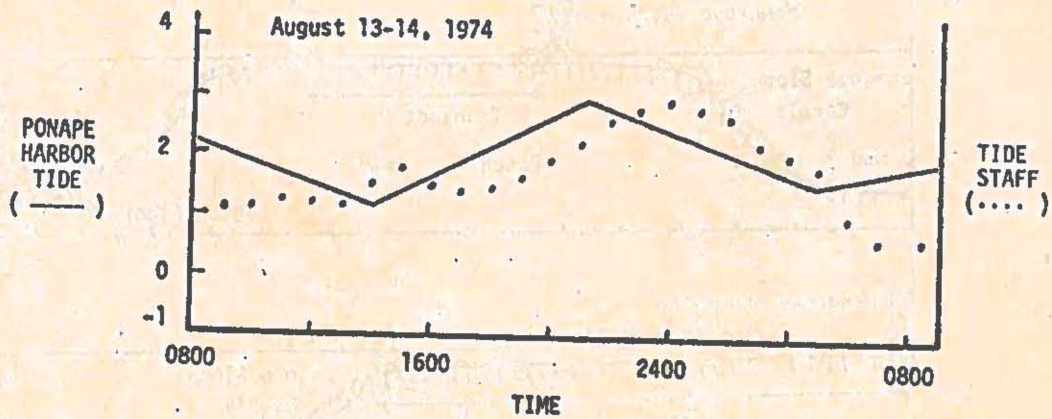


Fig. 4. Vertical profiles of Transects 1-6. Profiles of Transects 1, 5, and 6 were run along the transects lines whereas profiles 2, 3 and 4 were run at right angles across the transect lines. See Figure 3 for transect and profile locations.



Drift	Start	ΔT	1 m Dist. (Naut.Mi.)	1 m Speed (Knots)	5 m Dist. (Naut.Mi.)	5 m Speed (Knots)	Wind Dir.	Wind MPH
1	0900	1:00	.10	.10	.04	.04	350	5.5
2	1000	4:10	.35	.08	.08	.02	020	2.8
3	1200	3:00	.18	.06	.15	.05	050	2.7
4	1400	1:45	.34	.19	.28	.16	-	0
5	1500	2:50	.13	.05	.34	.12	026	7.1
6	1800	2:10	.25	.12	.37	.17	024	8.3
7	2000	0:52	.18	.21	.11	.13	026	7.6
8	2100	1:57	.28	.14	.19	.10	035	6.6
9	2300	1:52	.12	.06	.21	.11	031	11.8
10	0100	1:58	.07	.04	.14	.07	034	5.8
11	0300	1:55	.14	.07	.26	.14	035	3.3
12	0500	0:53	.62	1.17	.05	.06	052	1.9
13	0600	0:55	.06	.06	.05	.05	070	0.5
14	0700	1:25	.05	.04	.08	.06	060	3.5

Fig. 5. Tide profile and drift drogue data, August 13-14, 1974.

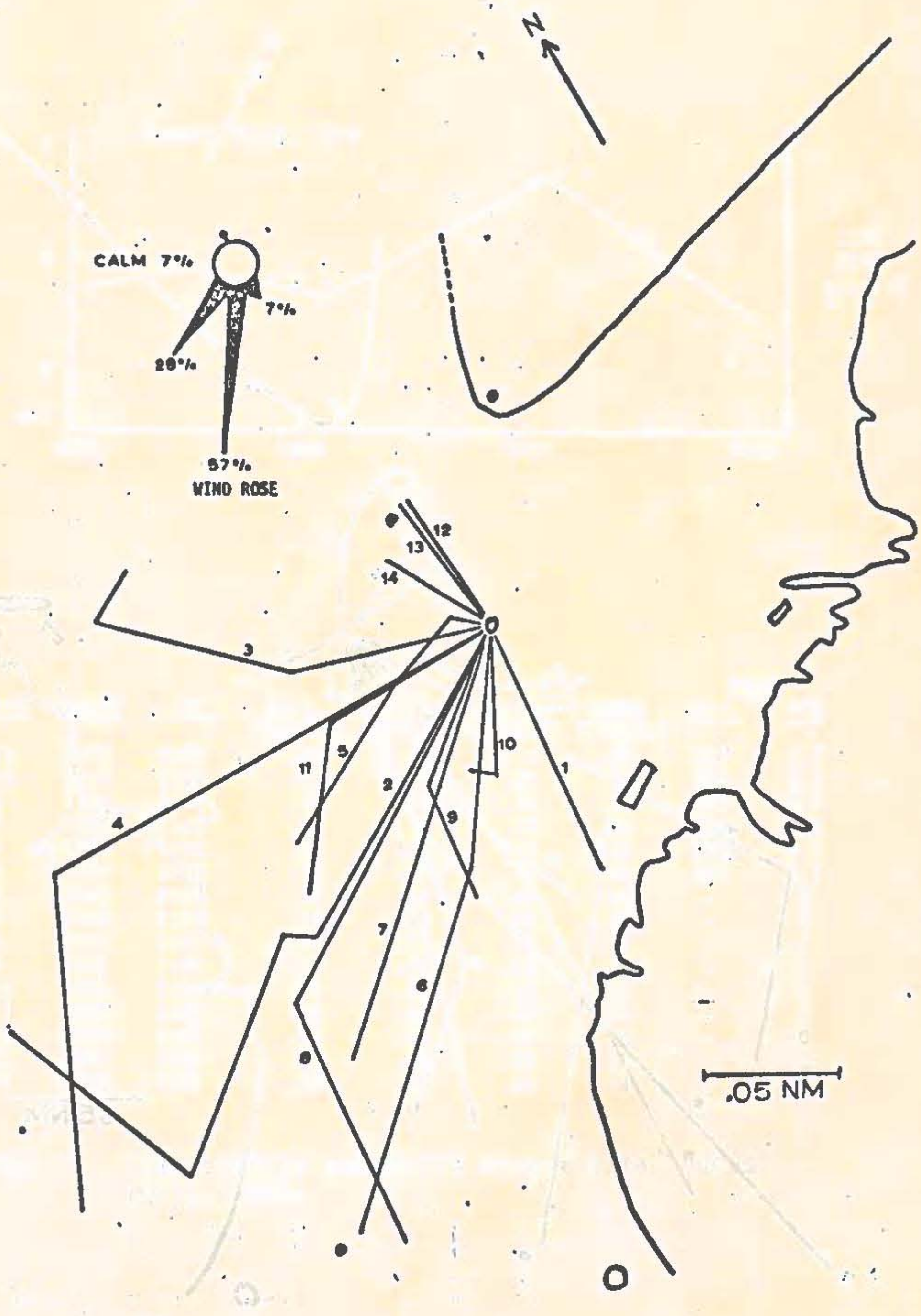
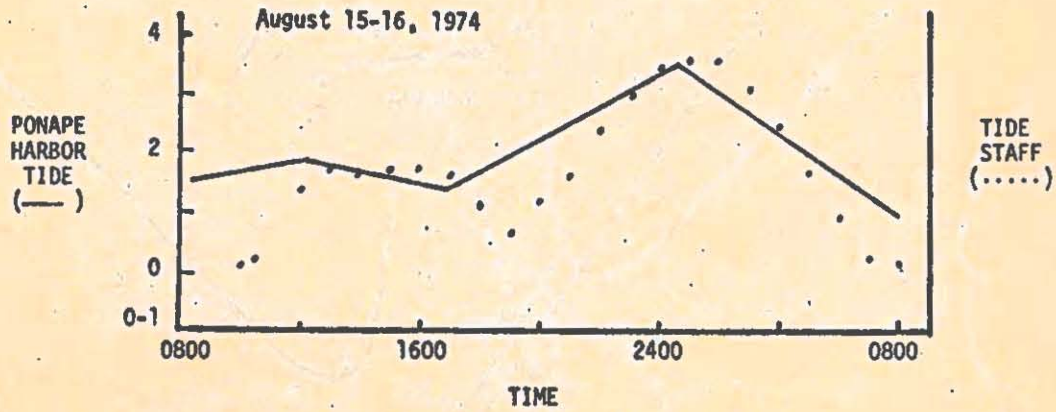


Fig. 6. 1-m drogue, August 13-14, 1974.

Fig. 7. 5-m drogue, August 13-14, 1974.



Drift	Start	ΔT	1 m Dist. (Naut.Mi.)	1 m Speed (Knots)	5 m Dist. (Naut.Mi.)	5 m Speed (Knots)	Wind Dir.	Wind MPH
1a	0900	2:00	.08	.04	.10	.05	303	2.7
1b	0900	2:00	.07	.04	.07	.04	303	2.7
2	1100	2:00	.10	.05	.14	.07	309	3.4
3	1300	1:00	.10	.10	.10	.10	290	4.5
4	1400	1:00	.09	.09	.12	.12	290	4.7
5	1500	3:00	.13	.04	.18	.06	303	1.1
6	1800	2:00	.10	.05	.09	.05	-	0
7	2000	2:00	.16	.08	.07	.04	-	0
8	2200	1:00	.17	.17	.17	.17	-	0
9	2300	1:00	.17	.17	.16	.16	-	0
10	2400	2:00	.14	.07	.13	.07	-	0
11	0200	2:00	.08	.04	.07	.04	-	0
12	0400	2:05	.08	.04	.09	.04	-	0
13	0600	1:00	.16	.16	.08	.08	-	0
14	0700	1:45	.34	.19	.25	.14	-	0

Fig. 8. Tide profile and drift drogue data, August 15-16, 1974.

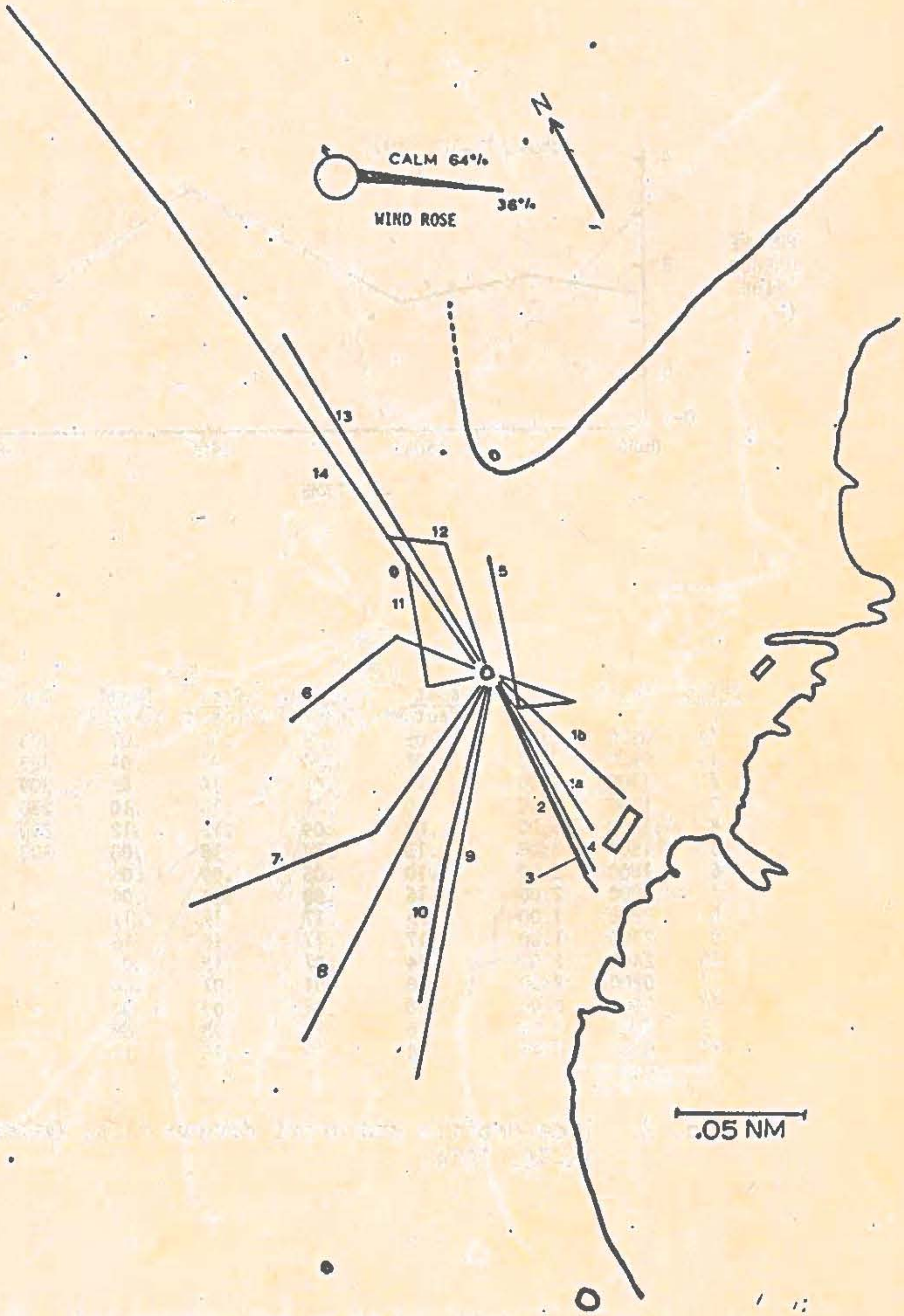


Fig. 9. 1-m drogue, August 15-16, 1974.

Fig. 10. 5-m drogue, August 15-16, 1974.

PLATE I

Fig. 1. Campsite on pipeline jetty during 24-hr current studies.

Fig. 2. View of jetty and shore.

PLATE II

Fig. 1. Boat used in current and biological studies.

Fig. 2. Typical mangrove stand (Rhizophora) which lines the edge of the fringing reef platforms.

PLATE III

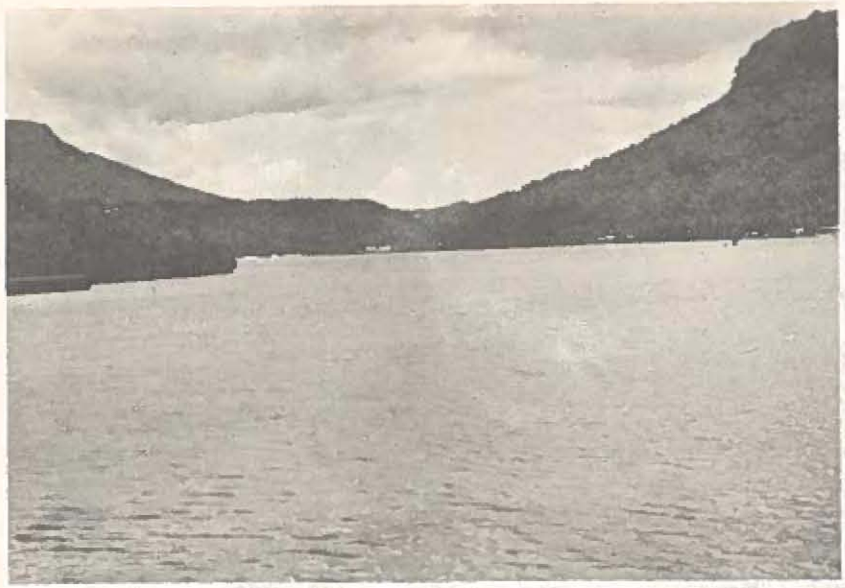


Fig. 1. Southwest view of Tuanmokot Channel.

Fig. 2. North View of Tuanmokot Channel.

PLATE IV

Fig. 1. Site of dredging operation at south end of Tuanmokot Channel.

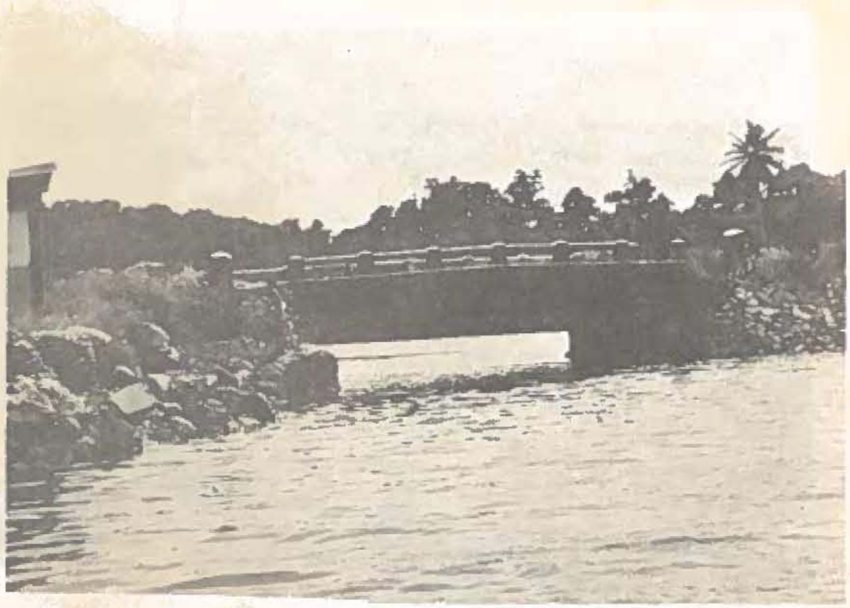


Fig. 2. Only opening to Mokota Channel.

PLATE V

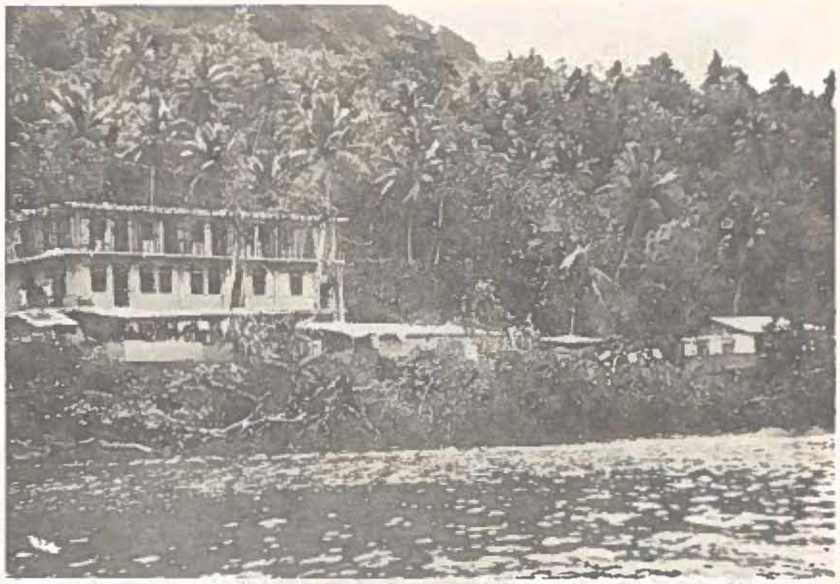


Fig. 1. Hotel under construction on western bank of Tuanmokot Channel.

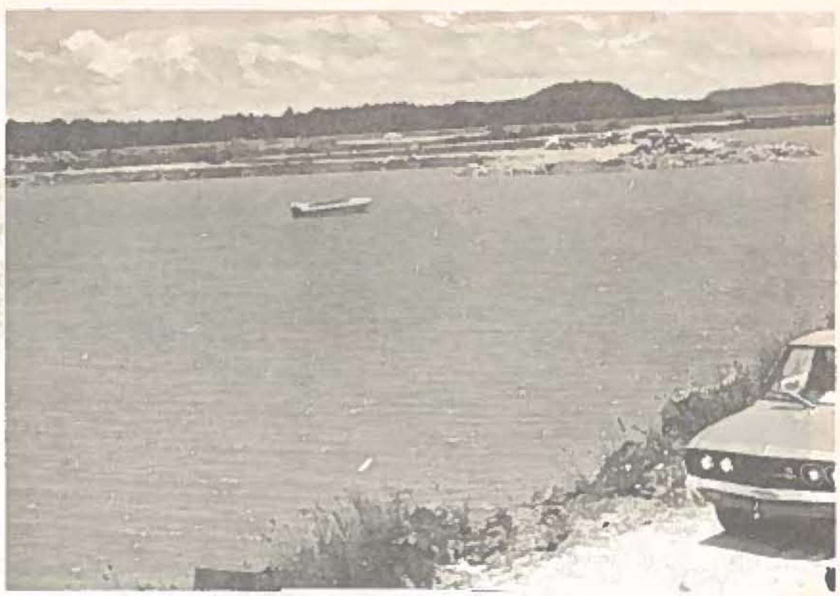


Fig. 2. Small boat harbor between airport causeway and Tuanmokot Channel.