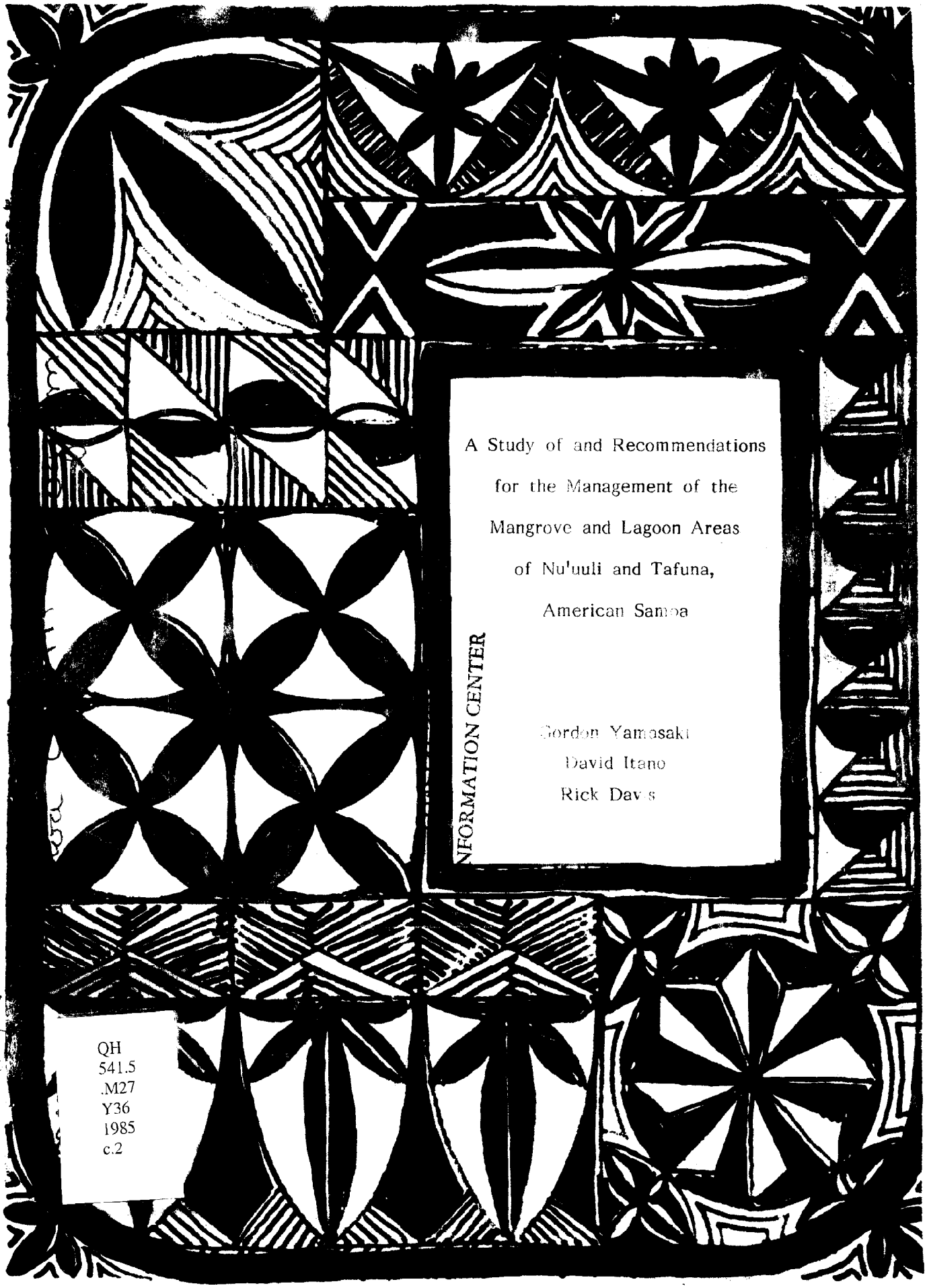

A Study of and Recommendations for the Management of the Mangrove and Lagoon Areas of Nu'uuli and Tafuna, American Samoa

Gordon Yamasaki
David Itano
Rick Davis

NFORMATION CENTER

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FINAL REPORT

A Study of and Recommendations for the Management of the Mangrove and Lagoon Areas of Nu'uuli and Tafuna, American Samoa

March 1985

Supposed to be ... Dec. 20, 1984

submitted by:

Gordon Yamasaki

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Rick Davis

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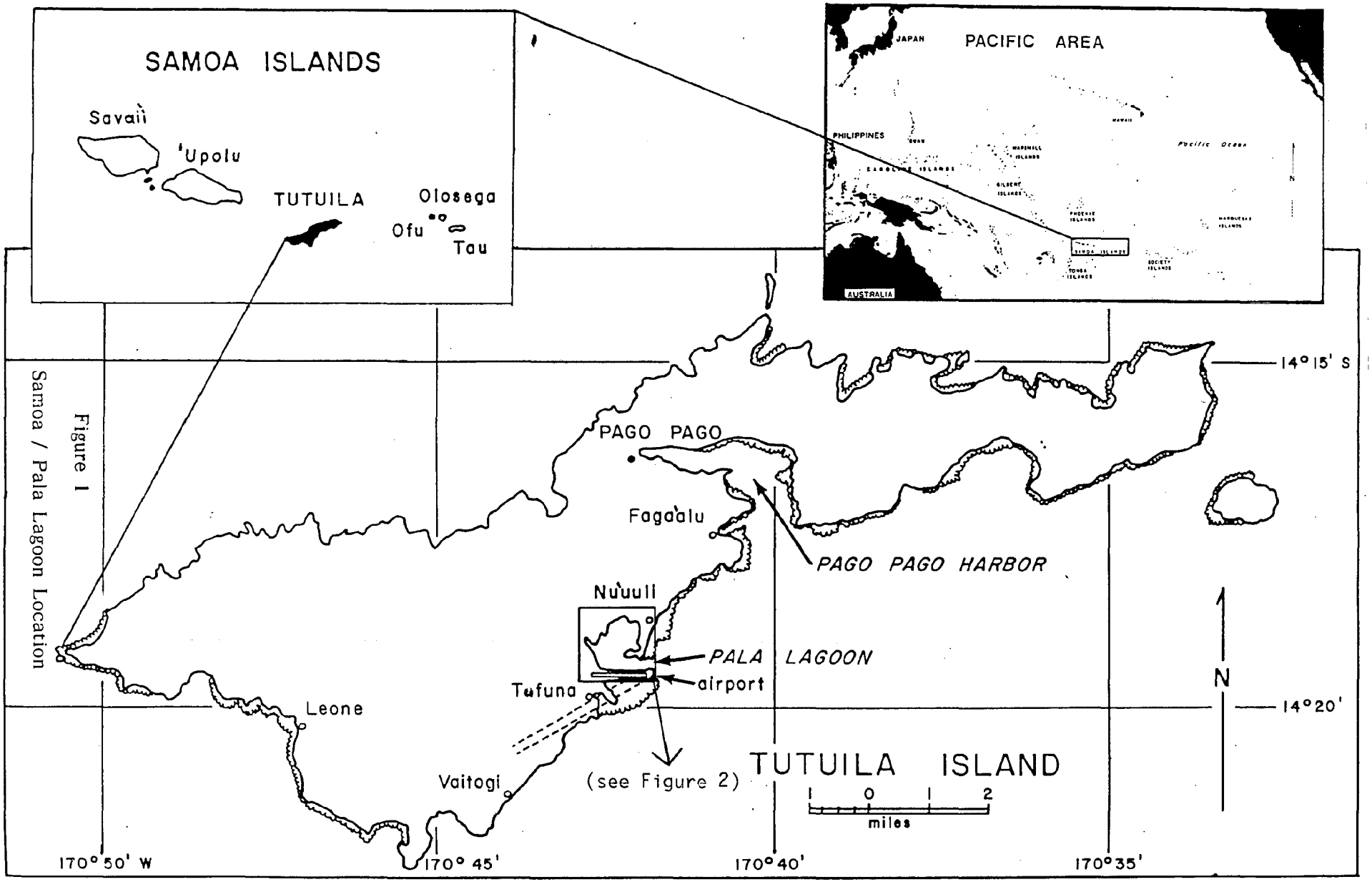
SAMOA ISLANDS
Savaiʻi
ʻUpolu
TUTUILA
Olosega
Ofu
Tau
PACIFIC AREA
JAPAN
PHILIPPINES
AUSTRALIA
Figure 1
Samoa / Pala Lagoon Location
14°15' S
PAGO PAGO
Fagaʻalu
PAGO PAGO HARBOR
Nuʻuuli
PALA LAGOON
airport
Tafuna
Leone
Vaitogi
(see Figure 2)
TUTUILA ISLAND
0
2
miles
N
14°20'
170°50' W
170° 45'
170°40'
170°35'

PREFACE

The following report was prepared under a grant from the Office of Development and Planning with funds provided by the Office of Ocean and Coastal Resource Management.

This study was conducted during a three month period from October, 1984, through January, 1985. The purpose of the project was to compile a comprehensive report of various characteristics of the mangrove and lagoon area known as Pala Lagoon and to make recommendations for its future management.

The major portion of this study is the result of a series of seven water samplings which were analyzed for coliform pollution and chemical content. All samples were collected using an inflatable raft. Coliform testing was carried out at the local public health water laboratory. Chemical samples were analyzed by AECOS laboratories in Hawaii. Other data gathered during the project were: levels of dissolved oxygen, water temperature, salinity, depth and secchi depth.

Seining was done to determine the diversity of fish species in specific areas of the lagoon.

A use survey was written and distributed to residents around the lagoon area. About 25% of the surveys were completed and returned. They were analyzed to determine the uses made of the

lagoon and resident' attitudes regarding several significant questions relating to lagoon use.

Extensive field walks were conducted along the inner and outer edge of the mangrove area to determine the general condition of the mangroves and associated lagoon areas.

Observations, interviews, and photographs were taken on numerous trips to the lagoon area to add to information already known about the lagoon. A slide program, depicting the uses, abuses, and problems within the lagoon area, was prepared from the photos, to present to the village councils and other decision makers.

An unexpected opportunity to gain additional information arose during the study when the Department of Public Works contracted with R.M. Towill Corporation for an aerial survey of Tutuila. It became possible to compare an aerial photograph taken in 1971 to one taken during the survey in December 1984 to determine the amount of "development" during the ensuing thirteen years and to see whether any impact on the mangrove and lagoon areas could be determined.

A mapping survey of the mangrove area was also carried out at the same time as this study. This survey map was used to determine the lagoon's size and was compared with the aerial surveys, earlier land surveys, studies, and mappings.

An extensive literature search, both specifically on Pala Lagoon, and generally about mangrove and wetland ecosystems, was carried out, and some of that material is presented in this report.

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Plate 1

AERIAL PHOTO - 1984

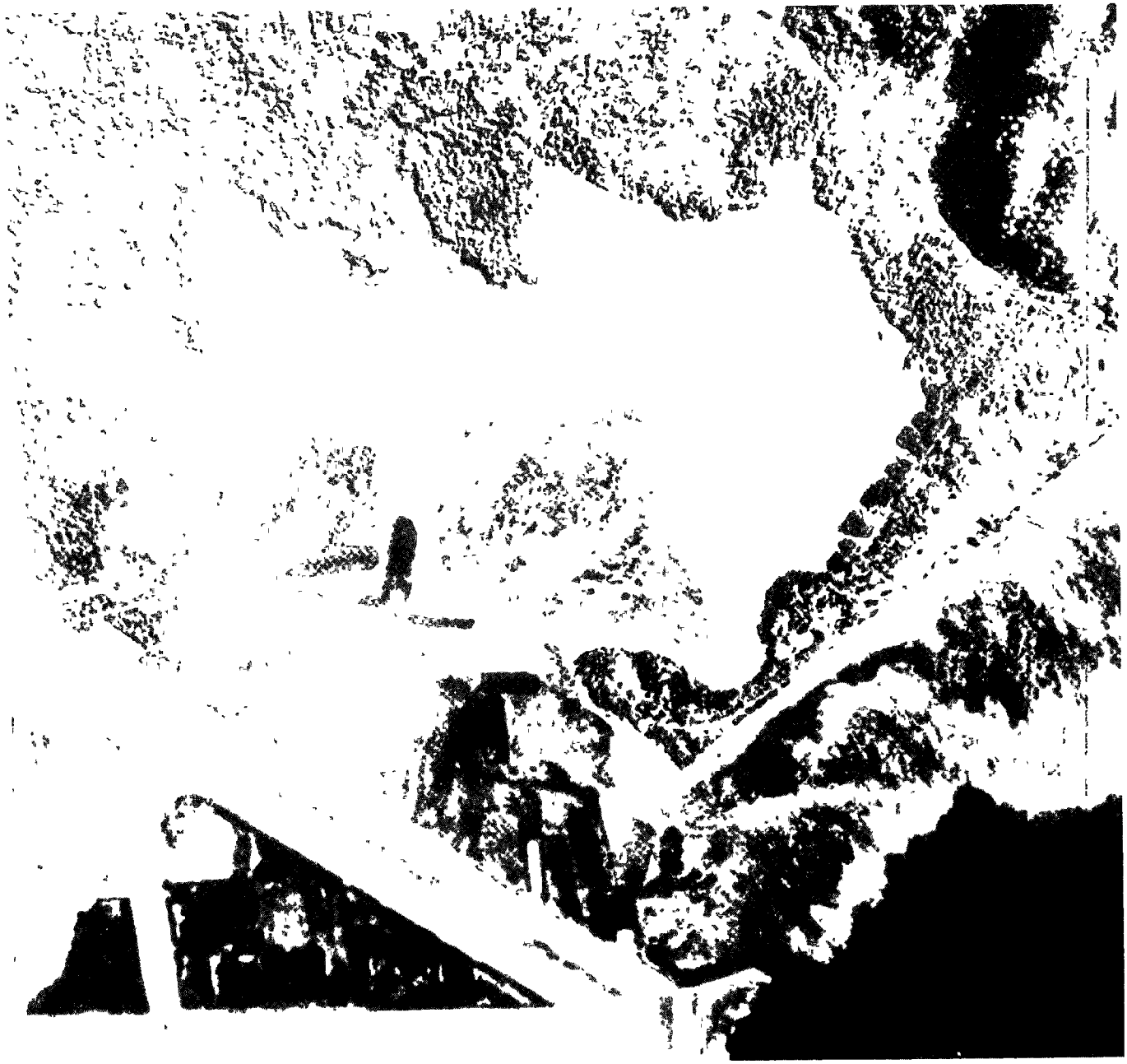

Plate 2

AERIAL PHOTO - 1971

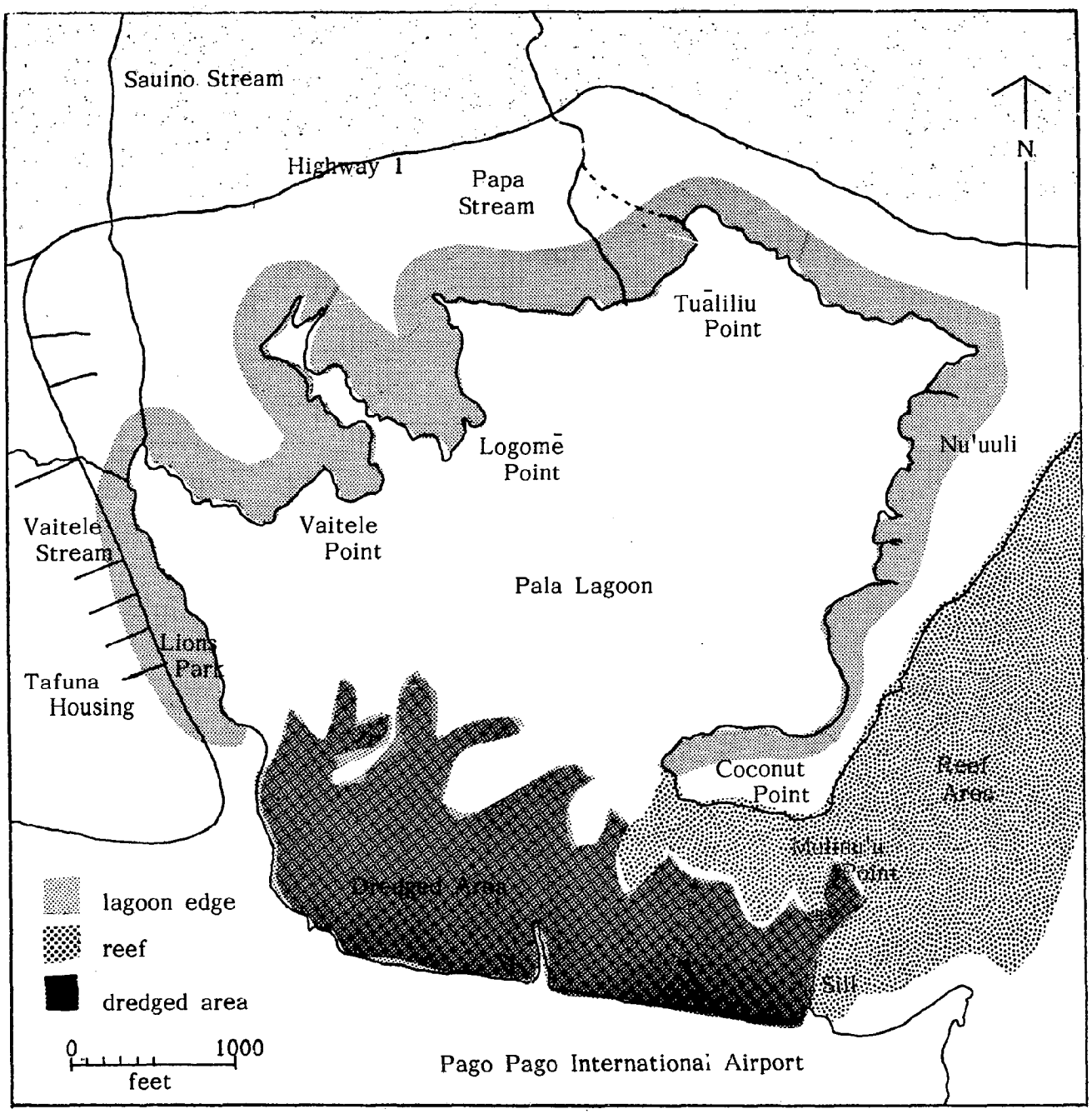

Figure 2

PALA LAGOON AREA

INTRODUCTION

Pala Lagoon is the only large, well-protected lagoon on Tutuila. It is roughly circular, approximately one mile (1.6 km) across, and has a surface area of about .75 square mile (2 sq.km.). (See Figure 2) Depths within the lagoon vary from 1 to 5 feet depending on the tide. The deepest areas next to the airport were dredged when the runway was built in the early 1960's, to obtain fill material for the runway and other building projects. Although the runway construction blocked about two-thirds of the lagoon entrance, water still flows in and out through the remaining channel.

The entrance to the lagoon is approximately 1200 feet wide with most of it a shallow reef top 1-3 feet in depth. There is a channel along the airport side of the entrance which is approximately 10-20 feet deep except for a shallow sill located about half way up the channel. The sill and reef top greatly affect the flow and mixing of the tidal waters in the lagoon (Helfrich,1973). The channel is about 20-40 feet wide until it reaches the inner dredged areas. Helfrich also indicates that the inflow on each tidal cycle is about 40 percent of the lagoon volume. Due to the sill, mixing of the incoming water and the lagoon water is extensive. However, it limits the flushing of water along the margins and northern shore of the lagoon. Mean residence time for water in the lagoon was figured to be about 30

hours, but there is a great difference in residence time of inner lagoon and outer lagoon waters. The inner lagoon residence time was estimated by Helfrich (1973) to be between 33 and 165 hours.

Along the eastern and northern shores of the lagoon, extensive stands of red (Rhizophora mangle) and oriental (Bruguiera gymnorhiza) mangroves cover an approximate area of 90 acres. (See Figure 3)

The northern shore has several streams which carry freshwater into the lagoon. In addition to the larger Papa and Vaitele streams, there are a number of small streams. Except for the Papa, the streams flow only during rainy periods, which are frequent; the average yearly rainfall is nearly 200 inches. The Papa stream has been diverted from its original path over the past 13 years and is now forming a new delta. (See Figure 2 and Plate 2) A "spring" enters the lagoon approximately one hundred yards from the Vaitele Stream in Lions Park. Its origin has never been conclusively determined (i.e., sewage, water main, true spring).

There is a public recreation/picnic area on the western edge of the lagoon which is regularly used by large numbers of residents. The lagoon is also used on a daily basis by many people for fishing, crabbing, and other food gathering activities.

The lagoon does not have as great a diversity of fish and invertebrates as found on reef areas, but it is a VERY important

nursery and spawning ground for many of the fish and invertebrates found on the reef.

The mangrove and lagoon areas are presently being affected by numerous activities carried out by man. The purpose of this report is to determine the extent of the threatening activities, to solicit opinions, and to offer options to resolve some of these problems.

The specific objectives of this study are: (1) to identify some of the economic, social, biological and esthetic values of the lagoon; (2) to identify mangrove boundaries and encroachment areas; (3) to determine what encroachment can be allowed without serious impact; (4) to define a "no-pass" line to limit development in unique areas; (5) to produce a visual presentation for decision makers; and, (6) to develop procedures for putting boundaries into the land use system.

The only previous study done on the lagoon was carried out by Philip Helfrich and a team of eight others in 1971. Their study was used to predict the impact of a small boat harbor and additional dredging within the lagoon. Portions of that study are replicated here to determine if there have been any changes in the water quality.

One major study, Wetland Vegetation of American Samoa (Whistler, 1976), reported on all wetland and mangrove areas of American Samoa and included excellent maps of the mangrove areas.

Wildlife and Wildlife Habitat American Samoa, Vol. I & II, reported on one plot in the large oriental mangrove area near the road entering Coconut Point.

Studies that have made reference to other areas in and around the lagoon include the American Samoa Coral Reef Inventory (AECOS, 1980), Wildlife and Wildlife Habitat of American Samoa, Volumes I & II (Amerson, et al. 1982), and "Evaluation of the Potential for Aquaculture in American Samoa" (Shleser and May, 1979).

General information on mangrove ecosystems indicates that 60 to 80 percent of commercially valuable marine fishery species use estuaries, salt marshes, mangrove swamps, and other coastal areas as habitats at some point in their life cycles (Council on Environmental Quality, 1981).

Mangrove ecosystems have been proven valuable in many ways. They act to prevent erosion and to recycle sediment washed down by streams. Juvenile fish and invertebrates are protected by these ecosystems from both weather and predators (Baines, 1981). One of the most valuable functions of the mangrove ecosystem is as a nursery and spawning area for many of the fish and invertebrates found on the reef outside the lagoon.

People also need to realize the health risk and cost of an unhealthy lagoon. An example of the cost of an unhealthy lagoon was the recent outbreak of cholera in Truk (1984), where many lives were lost, tourism and fishing industry declined.

There is a growing awareness of the value of traditional controls and village authority in environmental management in the Pacific islands (South Pacific Regional Environment Programme, 1981). Baines (1981) indicates that

> "to most, if not all, indigenous Pacific island communities, land, and all that grows upon it, together with the people who draw their sustenance from that land are, conceptually, one and indivisible. Adjacent mangrove and coral reef ecosystems are seen as integral components of that 'land', not as separate from terrestrial ecosystems by an upper tidal water level."

We feel in American Samoa these traditional practices and controls which were carried out by matai and village councils could and should be used to the benefit of the ecosystems and the people who depend upon them.

RECOMMENDATIONS

1) Landfilling, tree cutting and the use of Pala Lagoon as a dump site, should be stopped at once. The relationship between mangrove acreage and a lagoon's productivity has been well established elsewhere. Further decrease in the area of mangrove will definitely affect Pala Lagoon's usefulness as a nursery and feeding area for many of Samoa's reef and offshore fish. The protection of the lagoon is needed for the maintenance and productivity of coastal and offshore waters.

2) Hookup to the new sewer line (once it is completed in late 1985) should be mandatory for all families that live in and around the Nu'uuli area.

3) All piggeries located near the lagoon or near a stream should be relocated to safe and suitable sites. Drains for these should also be connected to the new sewer line.

* The above three recommendations are already part of the Environmental Quality Commissions (EQC) water quality standards for the lagoon, and the U.S. Environmental Protection Agency is presently funding the construction of the sewer line. The EQC hopes to obtain funds to carry out recommendations 2 and 3.

4) Beneficial uses such as recreation, subsistence fishing, and limited commercial activities on the lagoon should be encouraged, with the Nu'uuli village council and American Samoa Government (ASG) monitoring any activity (especially aqua-culture) to insure

they are consistent with the overall management goals of the area, as seen by the council and the government.

5) Development of educational materials and courses as well as the collecting of more data on the mangrove and lagoon ecosystem, should be a priority with the ASG. A better understanding by all of the residents of Samoa of the importance of the "Pala" will greatly enhance management objectives. The slides developed by this project are an example of materials that can be produced and used in schools and at public meetings.

6) Village council recommendations, based on their study of this report and viewing of the slide program, should be closely examined by relevant government agencies to determine if they can implement workable management practices that would be acceptable to all parties concerned.

7) All proposed land use activities in and around the area should be reviewed by both the ASG permitting agencies and the Nu'uuli village council, for consistency with federal, territorial and village regulations.

8) Appropriate ASG agencies should work closely with the pulenu'u (mayor) and village council in enforcement and monitoring of all illegal and unpermitted activities in the area.

9) The Fono should consider enacting stronger legislation on the management and uses of the lagoon and consider designating the

mangrove and the lagoon areas as a reserve or protected management area.

10) A bright band could be painted on trees that border the mangrove area to indicate areas and trees that need to be protected. Although unsightly, this would be one way of informing the public.

11) The U.S. Army Corps of Engineers, which has permitting authority over wetland areas, should become more involved by opening a local office to monitor and enforce land use activities in Pala Lagoon and other coastal areas to assure consistency with federal regulations.

12) The government needs to broaden its view when looking at management, preservation, and development of the entire area around the lagoon. Development of any adjacent portion of the lagoon, such as Lions Park, Tafuna Industrial Park, along the main road, the water shed valleys, or at Coconut Point, would all have a direct impact upon the lagoon and should be considered in the management plan of each of those seperate areas and in its entirety.

13) Based on the studies of the lagoon in this and previous reports, we would point out that the development of a shallow or deep draft harbor in the lagoon could not be caried out without doing irreparable harm to the lagoon and mangrove ecosystems. The benefits expected to accrue from such development should be

carefully weighed against the certain damage that would be done to this valuable and unique resource.

14) If more studies are carried out to determine the practacality and impact of a harbor in the lagoon, they must include an analysis of the depth, wave interaction, and swell configurations at the channel leading into the lagoon. Our observations, although not a part of this report, show this area to be as bad as the entrance to the wharf at Ta'u which is notoriously dangerous and very costly. Considering the size and number of ships and barges, and the cargo (oil a major one) going into the proposed harbor it is essential that a close look be taken at the area for the safety of entry and exit.

FIELD STUDIES & SURVEYS

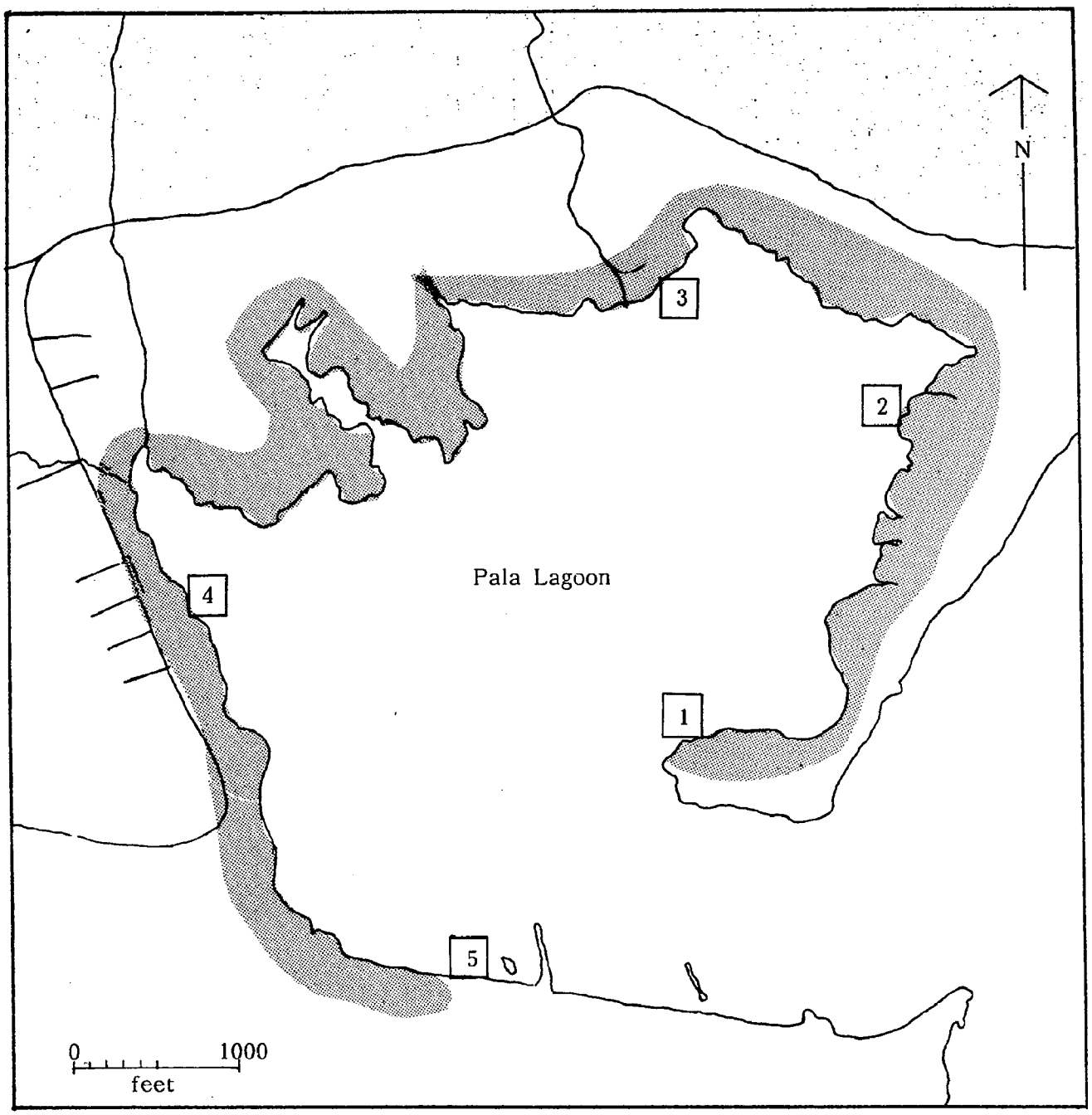

Figure 3

FISH SEINING STATIONS

FAUNA

'Fish'

A nylon beach seine was used to sample fish populations at five points within the lagoon. Similar sampling was done by Helfrich in 1971 using rotenone poison and concentrating on the deeper entrance channel stations of the lagoon. This study, however, was more concerned with the shallow inner lagoon. Therefore, the beach seine was considered a less drastic but adequate sampling method for our purposes.

The five stations were representative of the inner lagoon environments and included a shallow sand bar near the entrance to the outer coral reef (station 1), a mangrove-lined mud flat of the inner lagoon (station 2), a mud-and-rock-bottomed brackish area (station 3), a hard sand—bottomed rocky shoreline (station 4) and a rocky dredged area along the runway (station 5). (See Figure 3)

Seining operations took place during high tide due to the shallow nature of the inner lagoon. The net was composed of eight-millimeter knotless nylon mesh and measured ten meters long by two meters deep. The net was deployed parallel to shore approximately twenty-five meters from the beach and was slowly dragged shoreward. Specimens were counted and transfered to containers filled with a preservative.

TABLE 1

Summary of Sample Fish Populations in Pala Lagoon

Station	Description	No. of species	No. of individuals	Dominant species
1	clean sand bottom	5	51	mullet goat fish
2	mud bottom mangrove area	8	16	mullet ponyish
3	mud and rock bottom brackish	6	8	mullet anchovy
4	hard sand ledge/ rocky shoreline	4	45	silverside goatfish
5	sandy/rock bottomed dredged area	6	101	mullet cardinal fish

A summary of seining operations is listed in Table 1. A detailed species list of each station is included in Appendix A.

Escape and avoidance by fish going over, under and through the net was common but, it was felt that a representative catch was still obtained at each station. Gobies and blennies were noticably absent from all sampling efforts but were visually observed at all stations. Large jacks and adult mullets were often observed feeding in the lagoon and fishermen have reported catching and seeing sharks, but none was caught in the seining operations.

The results of our sampling indicated a surprisingly high species diversity in the inner lagoon (stations 2 and 3) and an obvious abundance of mullet in the lagoon ecosystem. Also of interest was an abundance of small predators within the lagoon. Juvenile

great barracuda (Sphyraena barracuda) were collected at four of the five stations and juvenile piscivorous jacks were found at three stations. The most common jack sampled (Caranx ignobilis) grows to well over one hundred pounds, and is an important game fish around Tutuila. Juvenile goatfish were also abundant in the lagoon. These fish indicate Pala Lagoon is not only a nursery and spawning ground, but also an important link in the life cycles of sport and commercial fish in the lagoon, on the reef and off-shore.

'Other Vertebrates'

A number of people have reported turtle sightings in the lagoon as far in as the area between Lions Park and Coconut Point. One turtle was sighted during a survey carried out during this project. Although no definite species identification was made on any of these sightings, general descriptions indicate that some could have been the endangered hawksbill turtle.

The area teems with birdlife and a number of sightings of rare and endangered species have been made around the lagoon and airport area. The birds, reptiles, amphibians, and other vetebrates have all been collected and well documented in the report by Amerson, et al. (1982) .

"Invertebrates"

An extensive area of the scyphozoan, Cassiopeia sp., was located near the southern tip of Coconut Point. Cassiopeia sp. are

tropical jellyfish that rest upside down on the bottom of shallow mangrove bays and lagoons (Barnes, 1974). They were most commonly found on sandy bottoms and were often associated with the calcareous algae, Halimeda sp.

Due to low salinity and high turbidity of the lagoon water, corals are virtually non-existant within the lagoon, although remnants of old coral reefs still exist in its upper reaches. Some live coral can be found in and around the entrance channel. No attempt was made to identify the corals or estimate their density, because this study was mainly concerned with the inner lagoon.

The holothurians Stichopus sp. and Actinopyga sp. were commonly observed in the outer lagoon areas near Coconut Point and the airport. Helfrich (1973) also recorded a few sightings of the sea cucumbers Polyplectara sp. and Holothuria atra from the inner lagoon and sand flats.

The most common gastropods observed were periwinkles, Littorina sp., and the archaeogastropod Nerita plicata. Periwinkles and barnacles were very common on the trunks and prop roots of many mangrove trees.

The mangrove oyster, Isogaomon sp., is common on rocks on the southwestern shoreline and the edible clam Gafrarium tumidum is abundant on the mudflats of the north and eastern shores of the lagoon.

Mantis shrimp, Lysiosquilla sp., live in burrows on the lagoon mud flats and many species of crabs inhabit the waters and shoreline of Pala Lagoon. Fiddler crabs, Uca sp., inhabit the entire intertidal zone of the lagoon. Land crabs (Cardisoma sp.) are common in all mangrove areas. The large mangrove crab, Scylla serrata, is a favorite local food item and is trapped in the lagoon with nets and wire mesh traps.

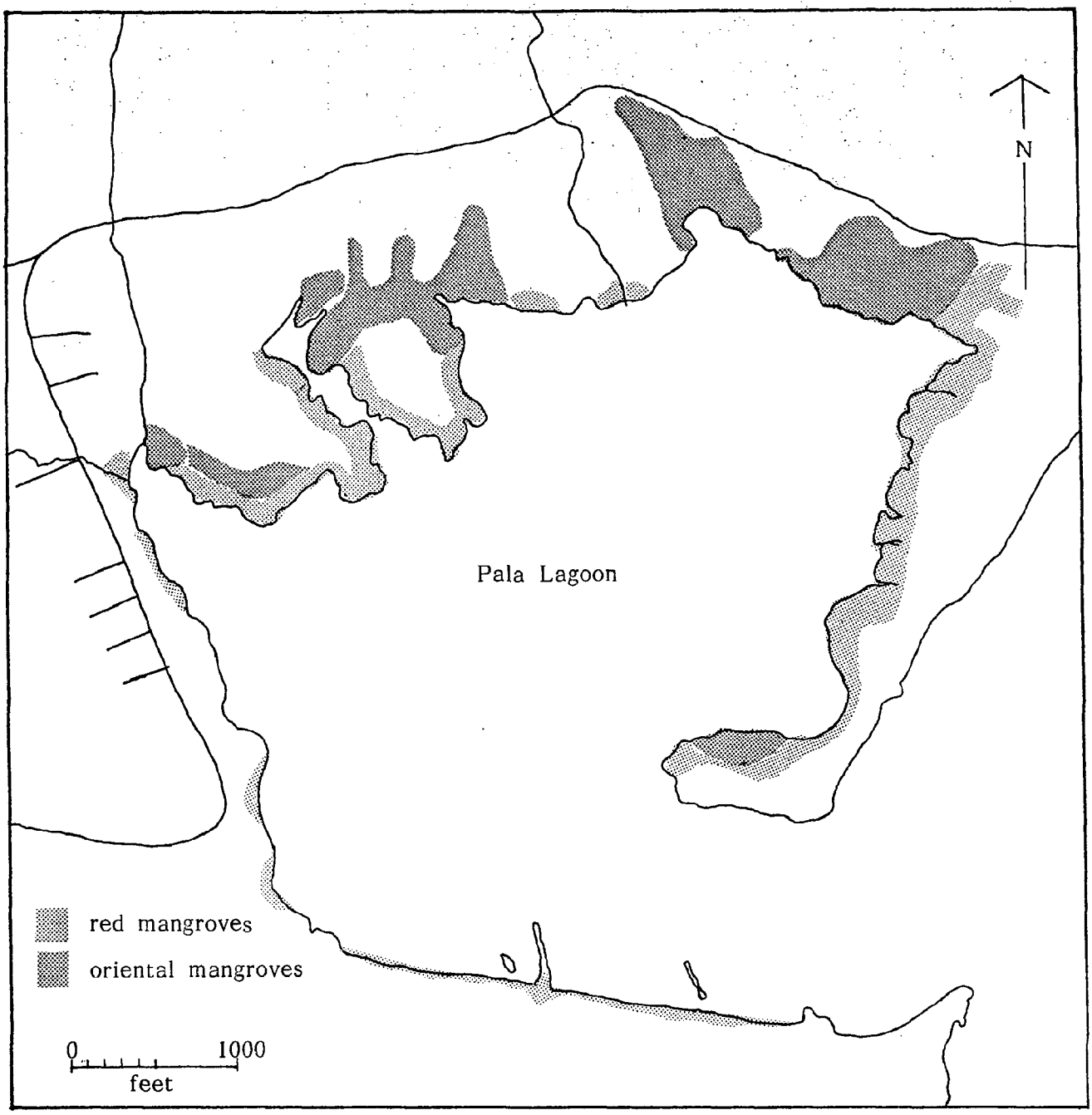

Figure 4

MANGROVE AREAS OF PALA LAGOON

FLORA

Another reason for special concern about Pala Lagoon is the flora found there. The mangrove forests on Tutuila are being threatened. Mangrove areas which existed in Pago Pago, Fagatogo, Faga'alu, and Utulei have been completely eliminated (Amerson, et al., 1982). The only major mangrove forest still existing is found in Nu'uuli (Pala Lagoon), with smaller patches in Aua, Vatia, Alofau, Masefau, and Leone. These areas however, are slowly being reduced.

A walking survey of the inner and outer edges of the mangrove area was conducted to determine the extent of the mangrove forest, to ascertain its condition, and to locate plant species that could be considered unusual.(See Figure 4, 5, and 6)

It was surprising to see the large extent of the mangrove area that has been untouched along much of the inner edges of the mangrove forest, but cutting and filling of mangrove areas was evident. (See Figure 5) Most of the cutting and filling has been for home sites. At several sites, trash was commonly used as the initial fill material over which layers of cinders were packed. In one particular area, behind South Pacific Traders, an extensive portion of the mangrove forest and lagoon has been cut and filled by this method. Along Coconut Point, many families use the edge of the lagoon as a dump site.

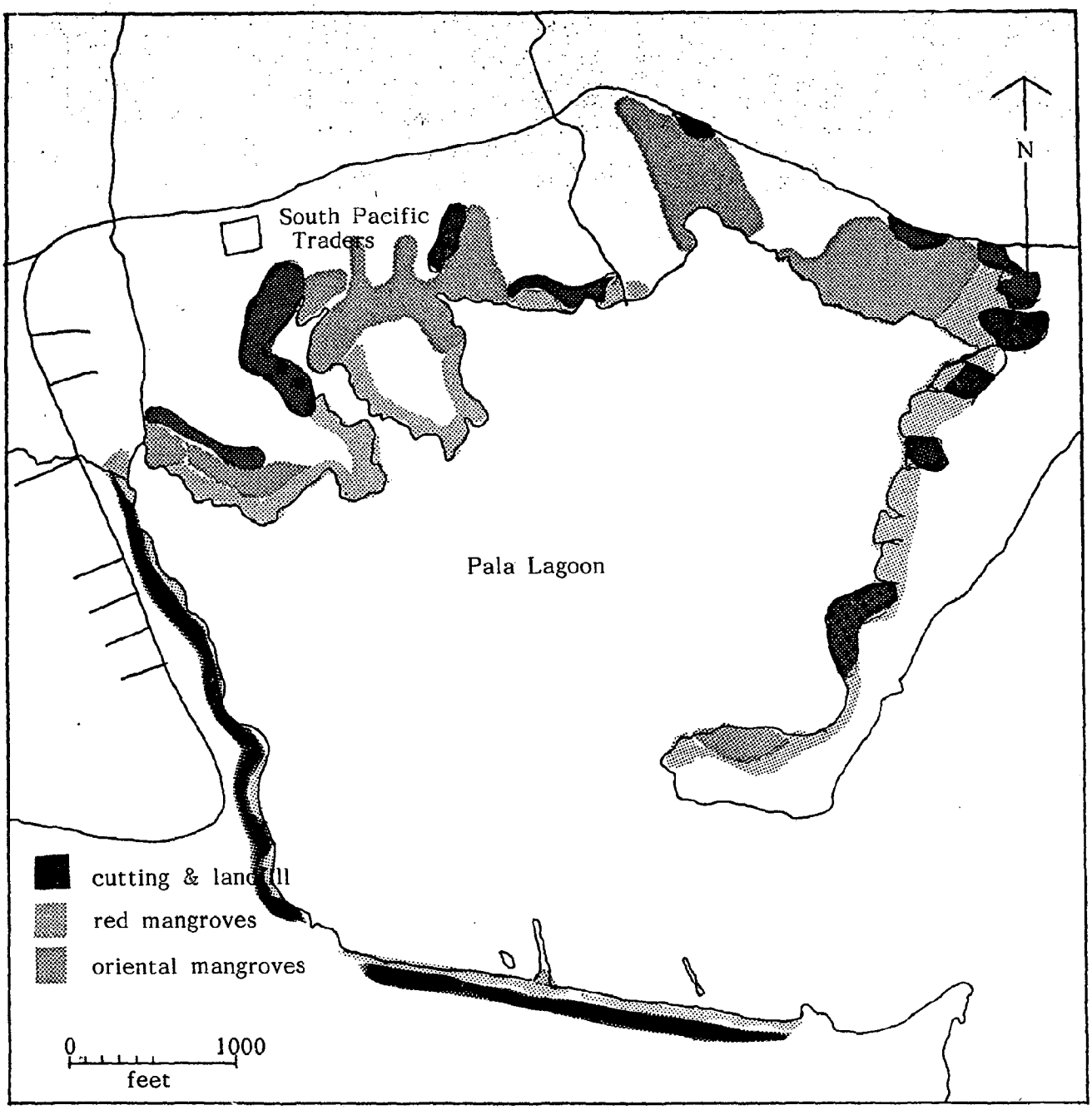

Figure 5

AREAS OF CUTTING AND FILLING

The largest of the oriental mangrove forests along the main road near the intersection to Coconut Point (See Figure 5), is slowly being cut and filled as the demand for new land and home sites increases. A large area near the end of Coconut Point, has a new stand of the oriental mangroves that, if left undisturbed, should be comparable in size to the older forest in the next 20-30 years.

The area around the lagoon also contains two and possibly three species of plants which are considered endangered or threatened (Amerson, et al., 1982). Attempts to locate and identify these areas have already been completed by Amerson, et al. These rare species along with all the other plants and animals in the lagoon ecosystem maintain a balance and have a purpose or 'niche'. If this balance is not maintained ALL the plants and animals will be affected. With cooperation and proper management by the surrounding villages and government agencies, future generations of Samoans and visitors may be able to see the natural wildlife and vegetation as it exists today in a 'natural' balance.

One of these rare species is Xylocarpus moluccensis, "le'ile'i" or the puzzlenut tree. Originally recorded only along the western end of the lagoon, it was also found along the lagoon edge of Coconut Point during this study. More than a dozen trees were counted in this one area (see Figure 6). Attempts to locate X. moluccensis along the western edge of the lagoon (Lions Park) were unsuccessful. They may have been cut during one or more of the fill projects along the lagoon in the last five years. It is

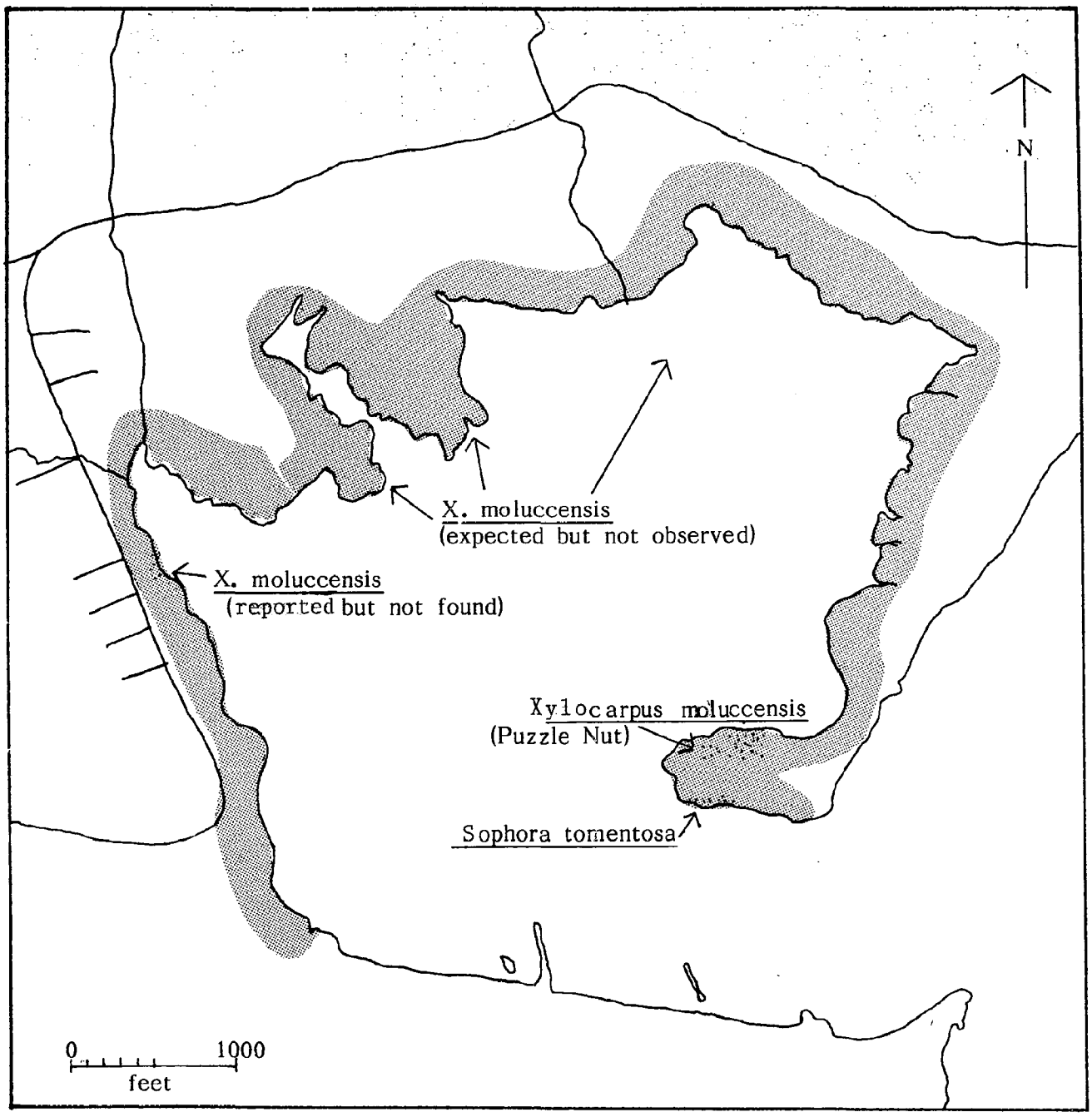

Figure 6

ENDANGERED AND RARE PLANT SPECIES

likely that the puzzlenut also exists along the northern shore of the lagoon although none was noted during our walks through the area.

Another rare plant indicated on Coconut Point, and located during this report, is the uncommon shrub, Sophora tomentosa, (See Figure 6) which is also reported to be found on Aunu'u (Amerson, et al., 1982).

Although not specifically identfied in the lagoon, Erythrina fusca, a leguminosae, has been identified once on the margins of American Samoa's mangrove forests and it would seem probable that it exists in the Pala Lagoon mangroves.

Indiscriminate land fill and clearing for homes or plantations could be extremely detrimental not only to the mangroves and water quality of the lagoon, but could also destroy some of the most unusual and unique trees and shrubs on the island. These rare species and the areas where they are found should be identified and the village council and land owners told of their unique value so they can be protected in the future.

Besides terrestrial plants, samples of algae were collected and identified (Table 2). Mud and sand flats compose much of the bottom within the lagoon where the red algae, Acantophora spicifera, dominates in cover. Halimeda sp. the calcareous

TABLE 2

Marine Plants Observed and Collected

Chlorophyta (green algae)
Caulerpa sp.
Enteromorpha sp.
Halimeda sp.

Phaeophyta (brown algae)
Dictyota sp.
Padina sp.

Rhodophyta (red algae)
Acantophora spicifera

Monocotyledon -Hydrocharitaceae
Halophila minor

green algae, and the "sea grass", Halophila minor, can be found along the sand flats bordering Coconut Point. The green, feather-like algae Caulerpa sp. and the brown algae Dictyota sp. and Padina sp. were found in the muddy bottom and rocky shoreline in the northwestern end of the lagoon as well as the sand flats of Coconut Point.

The rocky shoreline of Lions Park, forming the western margin of the lagoon, has a number of "springs" where freshwater constantly flows into the lagoon. Dense mats of the filamentous green algae, Enteromorpha sp., can be found on the basalt rocks and silty-sand bottom in the general vicinity of these springs.

It is interesting to note that Helfrich (1973) listed only four types of algae found in the lagoon. We were able to identify three additional genera, Dictyota, Padina, and Caulerpa. AECOS and Aquatic Farms, 1980, listed the sea grass Syringolium isoetifolium as being likely to be found in the lagoon habitat, but we were not able to find this species.

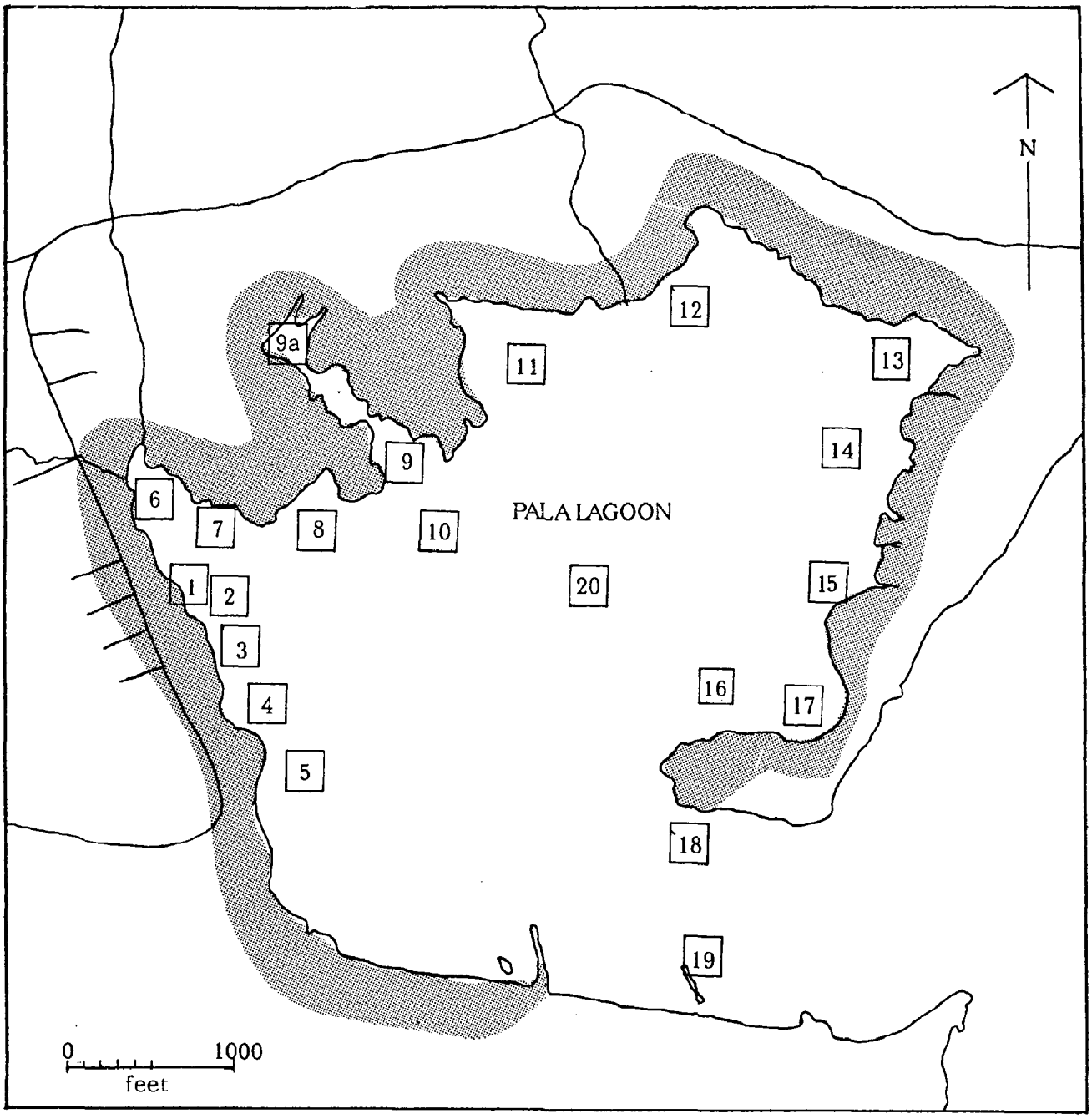

Figure 7

COLIFORM SAMPLE STATIONS

COLIFORM STUDIES

At the time of this survey, the watershed areas of Nu'uuli and Tafuna had no sewage treatment facilities except for the government housing units on the western edge of the lagoon. Sewage from the government housing units is carried to a primary treatment plant (settling tanks, and chlorination) located at the western end of the main airport runway and piped through an outfall approximately 100 meters offshore and would have no effect on lagoon waters.

Fecal coliform are bacteria found in the wastes of humans, pigs and other mammals. Their presence in the lagoon is a good indicator of the waste pollution from the surrounding villages. Four separate fecal coliform studies were carried out on the lagoon over a three month period. Twenty-one stations were studied each time (see Figure 7) in replication of the earlier study done on the lagoon by Helfrich in 1971. One additional station was studied, 9A, located inside stations 9 and 10. The presence of piggeries, a rubbish dump, landfill and several other factors prompted us to include this station. To facilitate the collection of water samples by boat, all samples were taken during high tide on the day of collection (indicated in appendix C).

During the collection phase, all samples were stored in a cooler. Immediately upon completion of collection, the twenty-one samples were taken to the hospital water lab for filtration and

TABLE 3

SUMMARY OF FECAL COLIFORM DATA, PALA LAGOON
(per 100 ml, tntc = to numerous to count)

Station	12/8	12/15	12/29	2/24	1971 Helfrich Data
1	29	0	tntc	4	15,0,15
2	*	0	tntc	0	0,7,25
3	2	0	tntc	0	2,24,20
4	*	0	tntc	0	1,3
5	0	0	tntc	0	1,0
6	0	0	tntc	2	0,36,120
7	0	0	tntc	0	11,5,25
8	0	0	tntc	0	4,2
9	8	0	tntc	0	2,2
9a	tntc	18	tntc	tntc	
10	3	0	tntc	0	1,7,1
11	6	2	tntc	0	2,2
12	12	5	tntc	0	1,1
13	18	0	tntc	0	2,1
14	3	0	tntc	0	1,1
15	*	0	tntc	0	1,1
16	2	1	tntc	14	0,1
17	*	*	tntc	16	9,4
18	0	0	tntc	0	0,0
19	*	*	tntc	0	0,0
20	0	0	tntc	0	1,1

placed on media plates. Due to the shortage of media plates on two days, several tests were not run and these are indicated in the table by an asterisk(*).

Well-mixed samples were filtered and analyzed according to the standard membrane filtration and plating technique (Millipore procedure). The volume of the samples was a standard 100 ml. Filtration and plating were usually completed within two to three hours from the time of collection. Plates of Bacto-M M-FC Endo-Broth and the filters were incubated in a water bath at 44.5 degrees Celsius for 24 hours.

A summary of the results is shown in Table 3 and Figure 8. Also included in the summary is the fecal coliform data from the Helfrich study (1973) for comparison purposes. A complete listing of the data can be found in Appendix C and Appendix D, including all the data on dissolved oxygen, salinity, depth, temperature, and secchi depth.

As seen from the data in table 3, there is a severe fecal coliform pollution problem in the lagoon, especially after a heavy rain. The 12/29 data was the second day of the two wettest days of December which brought in a considerable amount of sewage pollution. This was to be expected considering the number of piggeries and toilets that empty directly into the lagoon or into the river systems flowing into the lagoon.

Readings from thirteen of the twenty-one stations were about the

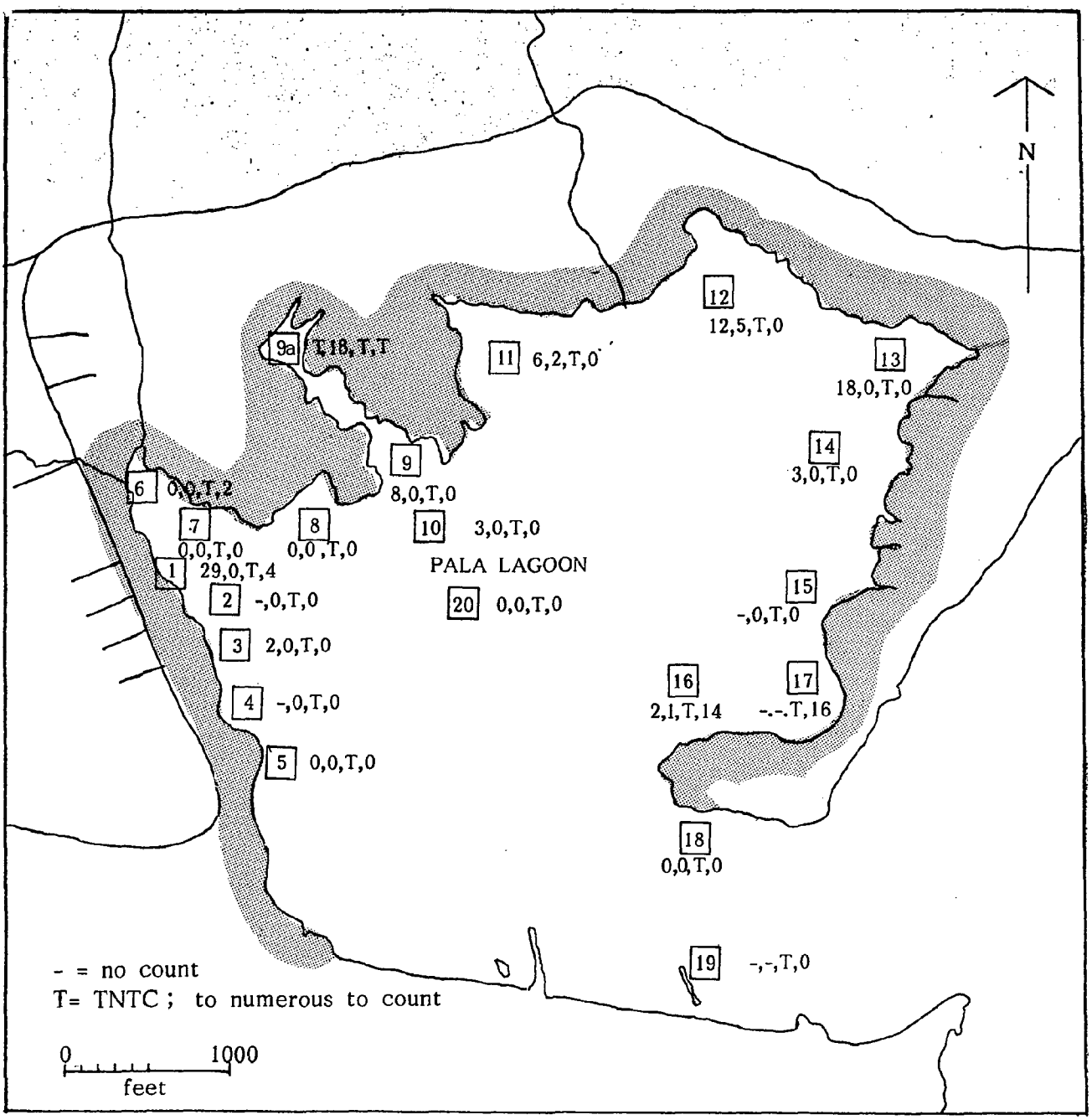

Figure 8

FECAL COLIFORM COUNTS BY STATION

(Sample Dates - 12/8, 12/15, 12/29, 2/24/85)

same as Helfrich on the drier days. Stations 1, 9, 9A, 11, 12, 13, 15, 16 showed markedly higher fecal coliform levels than in 1971.

The count at station 1, adjacent to a "spring" in Lions Park, suggests a pollution source of some sort that day (12/8). A long term study of the area around the fresh water inflow at station 1 needs to be carried out to determine if it is a constant pollution source for the lagoon.

Stations 9 and 9a through 13 are on the northern shore of the lagoon. This area receives most of its runoff from Papa Stream. Any runoff at all caused a marked increase in the coliform counts. The area around 9 and 9a is not part of the Papa Stream outflow and the pollution here is indicative of the piggeries in the area and the use of the small bay as an illegal rubbish dump.

The fecal coliform contamination at stations 16 and 17 (about half way out to Coconut Point) also needs further study as it was noticeable in this study as well as Helfrich's (1973). There are a number of piggeries visible along the shore and there is also a possibility that toilets and septic tanks seep into the lagoon because a number of open pipes were observed in the area. It will be interesting to note the changes in coliform counts when the new sewer lines are connected and the toilet wastes are no longer emptied into septic tanks and the lagoon.

TABLE 4

SUGGESTED STATISTICAL STANDARDS FOR STREAM WATER

American Samoa Water Quality Monitoring Handbook

Parameter	units	mean	Not to exceed 10% time	Not to exceed 2% time
Fecal Coliform	#/100 ml	100	300	600

The other stations seem to have adequate flushing to clear the areas of coliform pollution except on those days of excessive rain when the volume of water and degree of pollution exceeds any flushing that could take place.

As bacterial and viral pathogens are transported by water and include those causing typhoid fever, dysentery, cholera, and infectious hepatitis, the potential health dangers within the lagoon are extreme (Geldrich, 1966). And the organisms causing these health hazards can be found in sewage containing human and animal excreta; the need to stop the sewage pollution problem in the lagoon is obvious.

American Samoa's water quality standards set by the Environmental Quality Commission (EQC), as indicated in Table 4, could not be met by the water that now enters the lagoon. Violation of these standards is one of the reasons why the American Samoa Government has sought and obtained funding to put in the sewage system for the village areas around the lagoon.

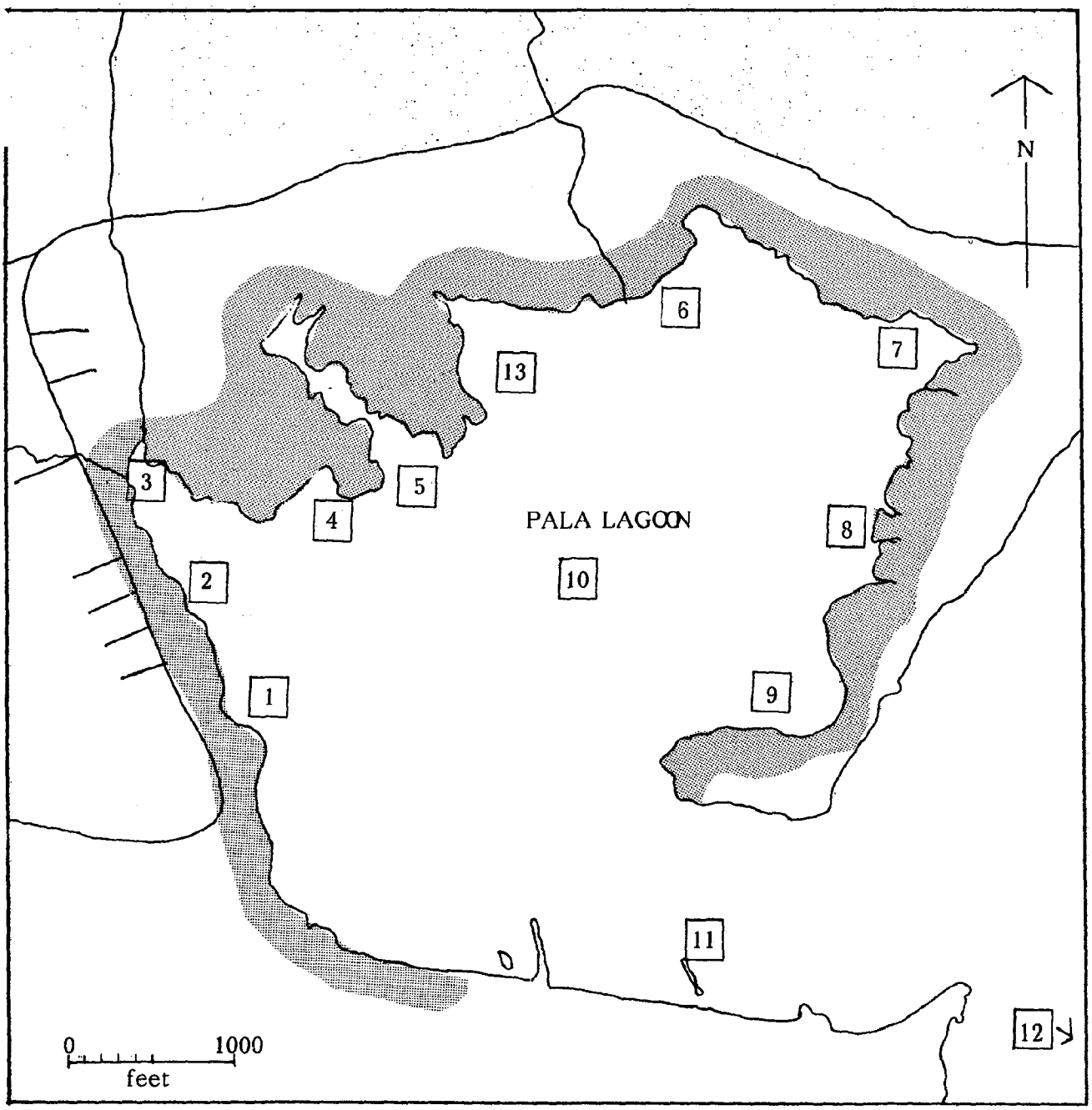

Figure 9

CHEMICAL ANALYSIS SAMPLE STATIONS

CHEMICAL STUDIES

This section of the study was performed to determine what, if any, changes have taken place in the chemistry of the lagoon water over the 13 years since the Helfrich report. Numerous tests were run. Nitrate-nitrites and orthosphosphates were measured and are nutrients that are present in most waters. Animal wastes washing into the lagoon would increase these nutrients. They also greatly determine the amount of algae and therefore the cholorphyll in the lagoon. The higher the concentration of the nutrients the more algae can grow. The temperature, depth, and salinity were taken to determine the water conditions in different areas around the lagoon. Dissolved oxygen was measured to see if there was any indication of oxygen depletion in different areas of the lagoon which would prevent animal organisms from suriving in those areas. The secchi depth was taken with a white disc which was lowered until it disappeared. It is used to indicate turbidity or clarity of the water.

Thirteen stations were studied; eight of which were replications of stations studied by Helfrich (1973) (See Figure 9), at each station water samples for nitrate-nitrites, orthophosphates, and chlorophyll-a, as well as temperature, depth, salinity, dissolved oxygen, and secchi depth were taken.

Duplicate water samples for nitrate-nitrite and orthophosphate

analysis were obtained in pre-labeled, 60 ml. plastic bottles at each station. Samples were immediately stored in an iced cooler for air shipment to AECOS Laboratories in Honolulu, Hawaii, on the same or following day after collection. Chlorophyll-a water samples were collected in 2-liter plastic jugs and taken to the L.B.J. Tropical Medical Center Water Laboratory for filtering. Water samples from each station were agitated, measured, and filtered through glass filters. Glass filters were then rolled and placed into labeled vials with acetone. Vials were then put into the iced cooler with the other samples for shipment to AECOS.

Each station was sampled twice; once in December and then again in January. The December 30th sampling was the day after the heaviest 24-hour period of rain that month. (See Appendix B) The January 19 sampling was after a four-day period of almost no rain.

The nitrate and nitrite results in Table 5 and Figure 10 show very high concentrations primarily along stations located on the western and north-western shores of the lagoon. Lower concentrations were obtained from stations along the east and north-eastern shores. (See Figure 10) As sea water has low concentrations of these nutrients, the lowest readings came from the station located in the channel leading out of the lagoon and the station in the open ocean. This corresponds with the data shown in Helfrich (1972). The channel showed the lowest nitrate and nitrite concentrations, the open

Table 5

NITRATE & NITRITE CONCENTRATIONS
(compared with Helfrich)

Sample Station	(sample dates) 12/30/84 (mg N/L)	1/19/85	Helfrich stations	2/29-31/72 (mg N/L)
1	2.23	.10	4	.07
2	1.44	.37	TC	.40
3	1.18	.14	4a	.20
4	5.37	.37	4b	-
5	2.41	.40	5	.10
6	.93	.04	-	-
7	1.67	.03	6	.007
8	1.80	.19	-	-
9	1.09	.07	7	0.00
10	1.89	.02	-	-
11	.13	.05	2	.02
12	.26	.12	1	.08
13		.28	-	-
Analysis date	1/3/85	2/4/85		

ocean tested slightly higher, and the inner, western and north-western areas of the lagoon had the highest concentrations.

In comparing the nitrate/nitrite concentrations from our study with those of Helfrich (1973), some interesting contrasts can be seen (See Table 5). The sampling on 1/19/85, a relatively "dry" period was the one most similar to the period of Helfrich's study, and does not show a great increase in the nitrate/nitrite concentrations except at station 5. Station 5 showed .40mg N/L. This can be compared with Helfrich (1973) which showed .10mg N/L at station 5 when he did the study in 1971.

The impact that the rains have on the lagoon should also be noted in Table 5. The concentrations of nitrate/nitrites after the

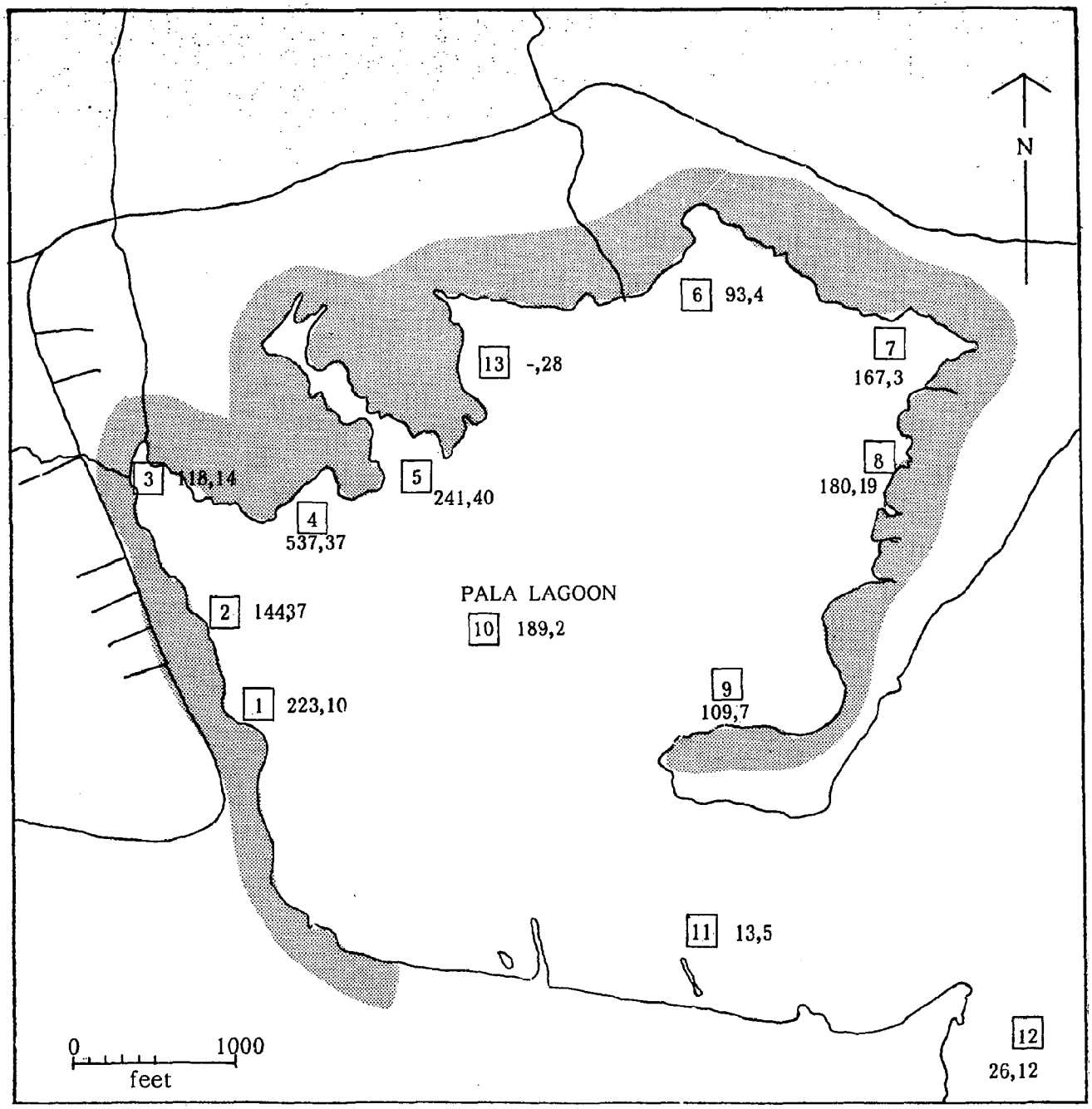

Figure 10

NITRATE/NITRITE RESULTS BY STATION
(mg N/L x 100)
(Sample Dates - 12/30/84, 1/19/85)

heavy rains in December were five to twenty times greater all around the lagoon. The amount of material, not only chemical, but also silt and mud, is astounding. Considering that rainfall in Tutuilla is between 125 to 200 inches per year, the yearly inflow of nutrients should have a great effect on the lagoon flora and fauna.

We believe that a large portion of this inflow is due to sewage that is carried into the lagoon via streams, septic tanks, piggeries, and dump sites along the shore. All these sources not only contribute to the previously mentioned fecal coliform counts, but also to the nitrate/nitrite concentrations within the lagoon.

The nitrate/nitrite increases at station 5, in particular, should be noted as this area also shows high levels of fecal coliform.

The largest chemical change over the past 13 years appears to be the phosphate concentrations. In comparison to Helfrich (1973) most of the concentrations on this report's "dry" day are two to ten times higher and on our wet day, four to ten times higher.(See Table 6 and Figure 11)

Table 6

PHOSPHATE CONCENTRATIONS

[compared with Helfrich (1973)]

Sample Station	(sample dates) 12/30/84 (mg P/L)	1/19/85	Helfrich Station	2/29-31 (mg P/L)
1	.46	.18	4	.04
2	.46	.24	TC	.12
3	.88	.39	4a	.10
4	.61	.22	4b	-
5	.67	.22	5	.08
6	.74	.18	-	-
7	.45	.26	6	.04
8	.40	.22	-	-
9	.30	.22	7	.02
10	.47	.12	-	-
11	.19	.13	2	.04
12	.16	.13	1	.04
13	-	.25	-	-
Analysis date	1/4/85	2/1/85	(AECOS)	

This is in part attributable to the larger population around the lagoon and the increased use of soaps and detergents which eventually find their way into the lagoon.

Helfrich (1973) concluded that the nitrogen content of the lagoon was the limiting factor for algae growth within the lagoon. Since our data does not differ greatly from his, it could be assumed that it is still the limiting nutrient within the lagoon.

It will be interesting to note the chemical changes that occur after completion of the new sewer system. If a large majority of the population connects into the sewer line, it is likely that the nutrient concentrations within the lagoon would decrease, and

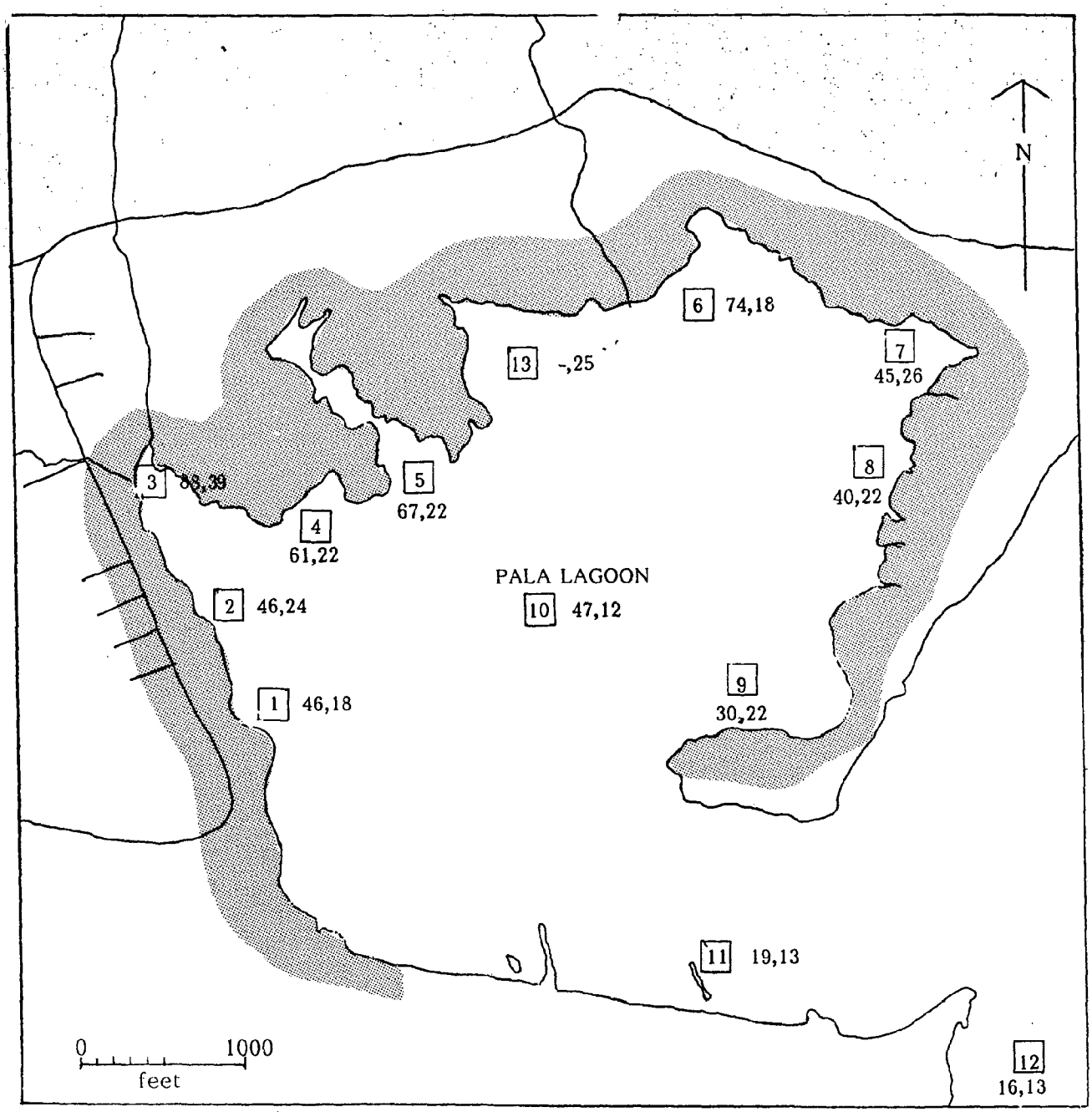

Figure 11

ORTHOPHOSPHATE RESULTS BY STATION
(mg P/L x 100)

(Sample Dates - 12/30/84, 1/19/85)

possibly improve the quality of the lagoon waters by decreasing the growth of algae and plankton that could deplete the lagoons dissolved oxygen supply.

Because of the lack of adequate data for chlorophyll-a, it would be difficult to make any conclusions at this time. The only sample was taken the day following a heavy rain and probably should not be compared with Helfrich (1973). (See Table 7) We were unable to take a second sample for chlorophyll-a during the second round of chemical tests due to the absence of glass filters. Several attempts were made to acquire these filters, but our efforts were in vain. Further study should be initiated to see if the chlorophyll-a levels have increased because it would have a definite impact on the water quality of the lagoon.

Table 7

CHLOROPHYLL A DATA
(comparison with Helfrich)
sample day: 12/30/84
test day : 1/8/85

Station	(g/L)	1971 (mg/m)	station
1	5.6	11.01	4
2	1.0	11.45	TC
3	.42	17.87	4a
4	3.8	11.36	4b
5	< .40	11.36	5
6	2.0	-	
7	7.2	12.79	6
8	51.8	-	
9	7.1	5.97	7
10	-	-	-
11	1.1	4.18	2
12	3.3	.55	1

With the government and canneries presently considering a major wharf development in the channel of the lagoon, it is important that more conclusive data be obtained on the present status of the lagoon and how it has changed over the past thirteen years. These data could then be used to estimate what the impact of a major wharf/dike development would have on the lagoon.

SOCIO-ECONOMIC USES

Recreational use of the lagoon is centered around Lions Park. It is a popular picnic spot and the tennis courts and children's playground are heavily utilized. Some people swim and wade in the lagoon near the park but many don't because of it's reputation as a polluted body of water. Kayaks, canoes, and rafts are sometimes launched here. Larger recreational boats are uncommon, probably because of the lagoon's shallow nature.

Pala Lagoon is also a major source of food and income for many of the nearby residents. Men, women, and children were observed setting crab traps, fishing with bamboo poles and modern spinning gear, and using monofilament cast nets and gill nets. The lagoon entrance is also a popular and productive fishing area. Spear fishermen with strings of reef fish were often seen while conducting this project. Many people take their catch home to eat, but clams and crabs can sometimes be seen for sale at the bus stop near the Tafuna turnoff.

Some of the detrimental uses of the lagoon include using it as a rubbish dump, as a site for piggeries, and as an area to fill for new building sites.

A general utilization survey was distributed to families in Nu'uuli and Tafuna who live on or near the lagoon. (See Appendix F & G) One hundred and fifty surveys were distributed, but only twenty-eight were returned or completed well enough to be of

Table 8

SUMMARY OF SURVEY QUESTION 1
In what ways does your family use the lagoon and how often?

Activity	% of families engaged in activity	Mean # of days/ year/family
Swimming	27	66
Fishing	73	117
Crabbing	64	109
Clamming	91	127

statistical value. This was not due to disinterest in the lagoon but due to poor communications with those distributing them. All surveys were filled out voluntarily; the identity of respondents is confidential.

The survey and comprehensive results of each question can be found in appendices F and G. The number of the question asked is noted in the text.

The results show an average 6.4 people per family, with an average of 3.4 members per family who directly used the lagoon for fishing and swimming. (Question 6) Most of the people surveyed were fairly young, with eighty-three percent of the people sampled less than 36 years of age.

Swimming is the least popular non-detrimental use of the lagoon; fishing and clamming are the most popular (See Table 8). Surprising to us and important to future planning in the lagoon

is the data showing the high proportion of families involved in clamming, fishing, and crabbing. Ninety-one percent of the families polled averaged 127 days of clamming per year, 73% of the families averaged 117 fishing days per year, and 64% averaged 109 days of crabbing per year. (Question 1)

Average catches of fish were 26.25 lbs/week, clams 4.75 baskets/month, and 9.9 crabs/week (Scylla serrata). (Question 2)

A wide variety of seafood is harvested from the lagoon. The animals most commonly mentioned in the surveys include, jellyfish, clams, crabs, jacks, and mullet as shown in Table 9. (Question 7)

Table 9

SUMMARY SURVEY QUESTION 7
What kind of fish and other marine life do you catch in the lagoon?

SCIENTIFIC NAME	COMMON NAME	SAMOAN NAME
Cassiopeia sp.	Jelly Fish	Alualu
Stichopus variegatus	Sea cucumber	Sea
Gafrarium tumidum	Clam	Tugane
Sipunculus rotumanus	Sandworm	Ipo
Lysiosquilla sp.	Mantis Shrimp	Ula
Cardisoma sp.	Land Crab	Tupa
Scylla serrata	Mangrove Crab	Pa'a limaga
Uncertain	Ocotopus	Fe'e
Chelon engeli	Mullet	Au'a, Fuafua
Liza vaigiensis		
Sphyraena barracuda	Barracuda	Sapatu
Caranx ignobilis	Jack	Lupo, Lupotā
Caranx melamphygus	Jack	Malauli
Mulloidichthys flavolineatus	Goatfish	I'asina
Lethrinus sp.	Emperor	Mata ele'ele
Hypoatherina ovalana	Silversides	Sali
Terapon jaruba	Terapon perch	Ava'ava
Uncertain	Sharks	Malie
Uncertain	Rays	Fai

Two thirds of the food caught is used for home consumption; one third of the catch is sold to augment family incomes. (Question 4)

Monthly earnings ranged from $.83/month to $300.00/month, with an average of $35.83/month/fishing family. (Question 5).

Everyone acknowledged that present fishing on the lagoon is not as good as it was in the past. Seventy-seven percent of the families polled felt that rubbish and pollution was the major cause of the decreased catches. (Question 3) Increased fishing, landfilling, and the use of dynamite for fishing were also mentioned as reasons for the lower catch rates.

Activities on the lagoon are listed in Table 10 in order of popularity. (Question 9) Eighty-one percent of the families collect firewood from the lagoon margins. "Togo", the Samoan word for mangrove, is a highly favored wood for the "umu" (ground ovens) and the making of charcoal. Nineteen percent of the families surveyed also indicated they have piggeries and rubbish dumps on the lagoon shores.

Those responding felt the most important priorities for the lagoon were the fishing, halting of pollution and protection of

Table 10

SUMMARY SURVEY QUESTION 9

Indicate which of the following activities your family does around the edge of the lagoon mangroves or the streams flowing into the lagoon?

Activity	% of families engaged in Activity
Piggery	19
Rubbish Dump	19
Land Fill	27
Home Site	58
Plantation	23
Fire Wood	81
Sewage Outlet	4
None of the above	4

the mangrove areas. Cutting the mangrove and filling the lagoon were listed as the least important activities. (Question 18)

There seems to be a great lack of knowledge and agreement concerning laws and regulations governing Pala Lagoon and the mangrove areas. (Question 12) Public health regulations and laws limiting dumping and filling were listed. Other families listed regulations prohibiting piggeries, mangrove cutting, and outsiders from fishing on the lagoon. Most of the people felt that the reasons for the regulations were to preserve the Pala for future use. (Question 13) Protecting the environment and preventing disease were also mentioned.

Question 20 asked for suggestions on better ways to make and enforce these regulations. . The most common response was to ask for the cooperation and support of the High Chiefs of Nu'uuli and Tafuna. Another common response was to let the American Samoa

Government take care of the problem. Higher fines, regular inspections, and citizen patrols were also suggested. One very interesting response suggested the creation of new recreational parks along the shoreline which would increase the public's interest in cleaning and improving the condition of Pala Lagoon. Visitors to the parks would be encouraged to report violations (e.g. trash dumping, filling, dynamite fishing) to the proper authorities.

Most of the people surveyed felt that the mangroves provide protection and food for fish and clams (Question 17) with eighty-nine percent of those surveyed, supporting a need to protect mangrove areas. One hundred percent of the surveyed families expressed a need to protect lagoon areas. (Question 16) Ninety-three percent wanted to increase their recreational and subsistence uses of the area. (Question 10)

Suggestions were solicited on how to improve the environmental conditions of Pala Lagoon. Thirteen families felt the need for everyone who lives near the lagoon to "pitch in" and help keep the area clean themselves. Seven families recognized the importance of supporting the new sewer project now under construction. Eight families wanted a conservation officer to be hired by the government to enforce the environmental laws through weekly on-site inspections and higher fines for violators (Question 15).

Many families that live next to the lagoon use the edge of the

mangrove area as a dump site for household rubbish. Some were obviously trying to use rubbish as fill to create more land. This was most evident behind South Pacific Traders, where there is a large illegal land-fill on which houses have already been constructed.

Many trees within the mangrove forest and lagoon have been cut and the clearings filled with rubbish and cinders to make home sites. New home sites are becoming a major problem in the mangrove area. On an island where land shortages exist, the need for fill and new land is understandable, but it could also mean the end of the mangrove ecosystems. Compromises have to be made to assure protection and restoration of mangrove areas. In the short three months of this study, three new fill sites were noted.

'General Observations'

In a walk along the edge of the mangrove forest many piggeries were seen. These are probably the major source of fecal coliform pollution in the lagoon and, thus, pose a substantial health hazard. It is doubtful that the coliform contamination of the lagoon will decrease to safe levels with the construction of the new sewer system for Nu'uuli and Tafuna unless these piggeries are also relocated or connected to it. People living around the lagoon have expressed the opinion that the sewer line is for the toilets and the laundromats and not for piggeries. Most residents are also concerned with the cost of connecting to the

main sewer. Fortunately, all existing houses will be connected free of charge to the sewer line once construction is completed. The American Samoa Government should also encourage families to have their piggeries hooked to the sewer line.

As can be seen from the above survey and observations, there are both beneficial and detrimental uses of the lagoon. If a compromise is not found and the detrimental uses stopped many of the enjoyable and beneficial uses of the lagoon will be jeopardized.

The surveys received and the interviews conducted with some residents, indicate a positive attitude. Most people want to clean up the lagoon and keep it as an environment for all to enjoy and use, however, many did not realize their activities were detrimental or were not willing to stop those activities (i.e. land fill, piggeries, dumping rubbish). The commitment on the part of the residents, matais, village councils, and government to the improvement and protection of the lagoon and mangrove areas is necessary to stop the continuing deterioration of conditions in the lagoon and to bring about improvements.

CONCLUSIONS

1. Pala Lagoon is a very important nursery and feeding area for fish and invertebrates. Many reef fish and some offshore pelagic fish depend upon the lagoon for at least part of their life cycles and are important to sport, subsistance, and commercial fisheries.

2. Pala Lagoon has the largest, best preserved, and most important mangrove system remaining on Tutuila. The mangrove trees provide protection from erosion and storm waves and offer protective habitats for many different marine organisms. The past destruction (elimination) of the large mangrove areas in Pago Pago Harbor increases the need to preserve the mangroves of Pala Lagoon. This unique mangrove area also contains some rare plant species that should be protected and preserved as they play a part in the ecological balance of the lagoon.

3. A subsistence fishery harvests fish, clams, crabs, jellyfish and sea cucumbers. Recreational fishing is conducted on a smaller scale along with a small amount of commercial fishing for clams, crabs, and sea cucumbers. Swimming and boating are not popular because of the fear of pollution and the depth within the lagoon. Responses from our use surveys indicated a widespread desire to clean up the lagoon so recreational and subsistence uses can be increased.

4. As can be seen from the data and observations, the fauna is

rather limited in diversity but the lagoon seems to be supporting healthy populations of the organisms present. Little seems to have changed from the data taken by Helfrich in 1971, although we did find a greater diversity of fish species in the inner lagoon.

It is difficult to measure the health of the population without further tests but it is likely that if the pollution of the lagoon and the destruction of the mangrove forest continue, the fauna of the lagoon could be severly damaged.

5. Coliform pollution within the lagoon has increased over the past thirteen years and is extremely serious during times of heavy rainfall. Many piggeries, an outhouse, and septic tanks were all observed and no doubt contribute heavily to the coliform levels within the lagoon. With the completion of the new sewer line for the villages of Nu'uuli and Tafuna scheduled for 1985, a marked improvement in the fecal coliform counts should be seen.

6. Verbal reports indicate that health problems have existed in the past, with reported cases of hepatitis from eating clams from the lagoon. Considering the data presented on coliform pollution, it could be assumed that the health hazard still exists.

7. The phosphate levels in the lagoon have increased greatly during the past thirteen years since Helfrich's study in 1971. The nitrogen levels also appeared to be higher. Much of this increase is due to the larger human populations around the lagoon

and the use of soaps and detergents. Pollutants enter the lagoon from laundromat, showers, sink drains, and septic tanks some of which empty directly into streams flowing into the lagoon. Although no definite results were determined, the increases in these two nutrients should correspondingly affect the growth of algae and plankton causing a decrease in the dissolved oxygen available to the flora and fauna within the lagoon.

8. The area around the lagoon is used by many families living adjacent to it as a trash dump. This creates a serious pollution and litter problem around the perimeter of the lagoon. Much of the trash floats away during high tide just to be placed back on shore by the prevailing winds. One large illegal "public" dump exists directly behind the South Pacific Traders and has increased by about 1-2 acres during the short three months of this study.

9. Cutting and filling of mangrove areas around the lagoon is a serious problem. Results of the land survey and comparison of aerial photos indicate a loss of approximately ten acres over the past fourteen years. Visual observations made on walks around the inner and outer margins of the mangrove area indicate numerous unregulated, unpermitted, and illegal landfills around the lagoon.

10. The uses of the mangrove and lagoon areas ranged from clamming and fishing, to cutting and filling. People around the lagoon use it heavily as a subsistence food source and as an area

for needs such as firewood and land. There was overwhelming support for protection of the lagoon and mangrove areas. People were definitely concerned about the lagoon and although responses indicated their detrimental activities were disturbing the lagoon, all agreed those activities should be stopped if it would improve the lagoon and mangrove environments.

11. Further development of areas in and around the lagoon should be scrutinized, as their impact could ultimately destroy an already fragile ecosystem. Helfrich (1973) suggests that detrimental effects could occur with the dredging and construction of a small boat harbor by increasing the lagoon salinity and lowering its water level by as much as 10cm. Our study indicates that the lagoon areas are already seriously affected and unless proper measures are taken soon, irreparable damage could occur.

The A.S.G. and cannery (Star Kist) are now investigating the possibility of dredging an even larger harbor than previously proposed and of constructing sea walls around it further affecting the area. We are in agreement with Helfrich (1973) concerning the importance of circulation and mixing of lagoon and sea water. The construction of such a harbor could choke off the supply of salt water into the lagoon and thereby create a brackish lake, or destroy the present sill which causes extensive mixing and flushing of the lagoon. Another consideration would be the change in current patterns which could seriously erode Coconut Point and some of the unusual vegetation on it.

APPENDICES

APPENDIX A

FISH COLLECTION DATA

Results of fish seining operations at six locations in Pala Lagoon, American Samoa using a 10 x 2 meter nylon beach seine. Station locations are shown in Figure 3.

Station 1

February 23, 1985. 11:00-11:45am. Sandbar on southwestern tip of Coconut Point. Depth 0-4 ft.

Scientific Name	Common Name	Samoan Name	No. & Size Range (mm)
Chelon engeli	Mullet	Aua	19 : 11-81
Hypoatherina sp.	Silverside	Sali	5 : 36-40
Mulloidichthys flavolineatus	Goatfish	I'asina	24 : 85-114
Sphyraena barracuda	Barracuda	Sapatu	2 : 115,126
Terapon jaruba	Terapon Perch	'Ava'ava	1 : 29

Station 2

February 23,1985. 12:15-12:40pm. Mangrove bordered mud flat at northeastern corner of the lagoon. Depth 0-3 ft.

Scientific Name	Common Name	Samoan Name	No. & Size Range(mm)
Apogon sp.	Cardinalfish	Fo	1 : 34
Caranx ignobilis	Jack	Lupo	2 : 65,73
Chelon engeli	Mullet	Aua	5 : 44-74
Hypoatherina sp.	Silverside	Sali	1 : 57
Leiognathus equulus	Ponyfish	Mumu	3 : 30-36
Liza vaigiensis	Yellowtailed Mullet	'Anae'afe	1 : 106
Scomberoides lysan	Leatherskin Jack	Lai	2 : 47,48
Sphyraena barracuda	Barracuda	Sapatu	1 : 128

Station 3

February 23, 1985. 12:50-13:30. Hard bottomed area near Vaitele stream at northwestern corner of the lagoon. Depth 0-3 ft.

Scientific Name	Common Name	Samoan Name	No. & Size Range(mm)
Chelon engeli	Mullet	Aua	2 : 46,70
Hyporhampus sp.	Halfbeak	I'usila	1 : 182
Istiblennius sp.	Blenny	Mano'o	1 : 51
Scomberoides lysan	Leatherskin	Lai	1 : 44
Sphyraena barracuda	Barracuda	Sapatu	1 : 130
Stolephorus sp.	Anchovy	Nefu	2 : 40,42

Station 4

February 23, 1985. 13:50-14:30. Hard sand bottomed ledge adjacent to Lions Park on the western shore. Depth 0-3 ft.

Scientific Name	Common Name	Samoan Name	No. & Size Range(mm)
Caranx ignobilis	Jack	Lupo	1 : 84
Chelon engeli	Mullet	Aua	1 : 70
Hypoatherina sp.	Silverside	Sali	33 : 46-61
Mulloidichthys flavolineatus	Goatfish	I'asina	10 : 88-108
Scomberoides lysan	Leatherskin Jack	Lai	1 : 48

Station 5

February 23, 1985. 14:50-15:25. Rocky bottomed dredged area adjacent to Pago Pago Airport at southern portion of the lagoon. Depth 0-4 ft.

Scientific Name	Common Name	Samoan Name	No. & size Range(mm)
Apogon sp.	Cardinalfish	Fo	23 : 20-49
Caranx ignobilis	Jack	Lupo	3 : 62-87
Chelon engeli	Mullet	Aua	67 : 14-48
Mulloidichthys flavolineatus	Goatfish	I'asina	6 : 82-107
Sphyraena barracuda	Barracuda	Sapatu	1 : 138
Terapon jaruba	Terapon Perch	'Ava'ava	1 : 14

APPENDIX B

CLIMATOLOGICAL DATA
(3 days prior to each sample day)

Date	Av.Temp. (F)	Rainfall (inches)	Av. Wind (mph)	Direction (compass)
12/5/84	81	.20	6.7	34
12/6	82	.53	9.3	33
12/7	80	2.13	7.3	33
12/8 *	81	1.64	5.3	31
12/12	80	T***	4.4	03
12/13	81	T	6.5	08
12/14	81	T	9.0	07
12/15 *	81	0	8.6	11
12/26	81	1.13	12.9	34
12/27	80	2.79	15.4	30
12/28	79	2.46	12.2	34
12/29 *	78	3.32	20.0	32
12/30 **	80	.02	7.0	21

Note: Highest 24hr rainfall for December was 4.72" on 12/28-29

1/16/85	80	.52	9.5	34
1/17	83	.24	15.0	34
1/18	83	.03	16.9	31
1/19 **	84	.29	14.6	34
2/21	80	.07	6.1	03
2/22	78	1.10	6.1	34
2/23	81	.18	10.8	01
2/24 *	83	.07	10.5	36

* Coliform sample day
** Chemical sample day
*** Trace

APPENDIX C

COLIFORM STATION DATA

Station/ Date		Dissolved Oxygen	Tempera-ture (C)	Salinity (ppt)	Secchi Depth (ft)	Depth (ft)
1	12/8	6.7	29.2	18	1	1
	/15	6.8	31.3	14	2.75	-
	/29	7.5	26.0	10	2.0	2.0
	2/24	8.5	29.5	0	3.0	3.0
2	12/8	7.4	29.1	20	2.5	2.5
	/15	-	-	-	-	-
	/29	7.0	26.5	14	3.0	3.0
	2/24	6.8	29.5	20	4.5	4.5
3	12/8	7.1	29.0	24	2.25	2.25
	/15	6.4	31.8	20	4.5	4.5
	/29	7.0	27.0	12	3.5	3.5
	2/24	6.7	29.0	20	4.0	4.0
4	12/8	5.9	-	-	3.0	3.0
	/15	-	-	-	-	-
	/29	6.8	26.5	19	3.0	3.0
	2/24	7.0	29.0	20	4.0	4.0
5	12/8	6.9	29.3	22	4.25	4.25
	/15	6.1	31.5	30	3.0	3.0
	/29	6.5	27.0	26	1.0	5.0
	2/24	6.8	29.0	25	5.0	5.0
6	12/8	7.0	30.0	05	3.25	3.25
	/15	6.6	31.8	12	3.25	4.75
	/29	10.2*	26.0	01	2.0	3.0
	2/24	7.2	29.0	15	-	-
7	12/8	6.2	30.0	21	3.5	3.5
	/15	6.5	32.O	16	4.0	4.0
	/29	8.0*	26.2	06	2.5	3.5
	2/24	7.1	29.0	20	-	-
8	12/8	6.4	29.6	22	4.0	4.0
	/15	6.3	32.2	25	3.75	3.75
	/29	7.4	26.0	10	2.5	3.5
	2/24	6.6	29.0	22	4.0	4.0
9	12/8	7.8	29.0	16	2.75	2.75
	/15	-	-	-	-	-
	/29	7.3	25.5	14	2.5	4.5
	2/24	6.6	29.0	20	4.0	4.0

* Bubble in DO meter resulted in inaccurate high readings.

Station/ Date	Dissolved Oxygen	Tempera- ture (C)	Salinity (ppt)	Secchi Depth (ft)	Depth (ft)
9a 12/8	6.6	29.5	10	-	-
/15	6.2	32.2	27	2.0	2.0
/29	7.7	25.5	05	1.0	1.5
2/24	7.1	30.0	15	2.0	2.0
10 12/8	6.5	29.8	25	4.0	4.0
/15	6.1	31.0	03	4.5	4.5
/29	7.1	26.0	15	2.5	4.0
2/24	6.2	29.0	25	5.0	5.0
11 12/8	7.2	30.6	12	1.5	1.5
/15	6.3	22.5	26	2.5	2.5
/29	7.1	25.5	11	2.0	2.1
2/24	6.9	29.5	20	2.5	2.5
12 12/8	6.6	31.1	21	1.25	1.25
/15	6.3	32.0	26	1.75	1.75
/29	7.6	25.0	04	1.5	1.5
2/24	6.6	29.5	20	2.25	2.25
13 12/8	6.5	33.0	18	0.5	0.5
/15	6.3	32.4	24	1.75	1.75
/29	7.6	25.5	05	0.9	1.5
2/24	6.8	29.0	20	2.0	2.0
14 12/8	6.4	31.5	26	1.75	1.75
/15	6.2	32.3	25	2.75	2.75
/29	7.2	25.0	06	2.1	2.3
2/24	6.7	29.0	25	3.0	3.0
15 12/8	-	-	-	-	-
/15	6.2	31.6	30	2.0	2.0
/29	7.3	25.5	13	1.5	1.5
2/24	6.8	29.5	20	2.5	2.5
16 12/8	6.5	30.5	26	4.25	4.25
/15	6.1	31.5	30	4.0	5.0
/29	7.2	25.0	12	3.0	4.0
2/24	6.5	29.0	25	4.0	4.0
17 12/8	-	-	-	-	-
/15	-	-	-	-	-
/29	7.5	26.0	10	1.75	3.0
2/24	7.0	29.0	25	5.0	5.0
18 12/8	6.3	30.8	28	5.0	5.0
/15	-	31.0	32	16.0	16.0
/29	6.5	26.5	24	3.5	3.5
2/24	6.2	29.0	30	3.0	3.0

Station/ Date		Dissolved Oxygen	Tempera- ture (C)	Salinity (ppt)	Secchi Depth (ft)	Depth (ft)
19	12/8	-	-	-	-	-
	/15	-	-	-	-	-
	/29	-	-	-	-	-
	2/24	6.1	29.0	30	5.5	5.0
20	12/8	6.2	29.0	33	-	-
	/15	6.3	31.0	30	3.75	3.75
	/29	6.7	26.0	19	1.75	2.0
	2/24	6.4	29.0	25	3.0	3.0

APPENDIX D
LABORATORY ANALYSIS REPORTS
(AECOS Labs, Honolulu)

Samples	NO + NO (mg N/L)		Orthophosphate (mg P/L)		Chlorophyll a (g/L)
sampled:	12/30	1/19	12/30	1/19	12/30
tested:	1/3	2/4	1/4	2/1	1/8
1a	0.214	0.010	0.046	0.015	5.6
b	0.223	0.010	0.044	0.018	
2a	1.125	0.036	0.046	0.024	1.0
b	1.144	0.037	0.045	0.022	
3a	-	0.014	0.088	0.039	0.42
b	0.118	0.013	0.088	0.027	
4a	0.505	0.037	0.061	0.022	3.8
b	0.537	0.037	0.060	0.021	
5a	0.241	0.040	0.064	0.022	<0.40
b	0.199	0.040	0.067	0.021	
6a	0.089	0.004	0.074	0.017	2.0
b	0.093	0.004	0.066	0.018	
7a	0.167	0.002	0.045	0.026	7.2
b	0.167	0.003	0.034	0.024	
8a	O.180	0.018	0.035	0.022	51.8
b	0.180	0.019	0.040	0.021	
9a	0.109	0.007	0.030	0.018	7.1
b	0.108	0.006	0.029	0.022	
10a	0.184	0.001	0.O43	0.012	-
b	0.189	0.002	0.047	0.012	
11a	O.011	0.005	0.019	0.013	1.1
b	0.013	0.004	0.018	0.011	
c	0.007	-	0.014	-	
d	0.005	-	0.013	-	
12a	0.026	0.012	0.016	0.013	0.33
b	0.025	0.012	0.016	0.010	
13a	-	0.027	-	0.022	-
b	-	0.028	-	0.025	

(Each sample was double tested for N & P to avoid test error)

APPENDIX E

CHEMICAL STATION DATA

Station	Date	DO	Temperature (C)	Salinity (ppt)	Secchi Depth (ft)	Depth (ft)
1	12/30	7.2	29	10	-	-
	1/19	-	29	30	4.0	4.0
2	12/30	7.1	29	08	-	-
	1/19	-	30	27	3.0	3.0
3	12/30	7.5	30	02	-	-
	1/19	-	30	26	2.5	4.0
4	12/30	7.5	29.5	03	-	-
	1/19	-	30.0	29	4.0	4.0
5	12/30	7.0	30.0	06	-	-
	1/19	-	29.5	29	3.5	4.5
6	12/30	7.5	31.0	04	-	-
	1/19	-	29.5	30	2.0	2.0
7	12/30	6.9	31.0	08	-	-
	1/19	-	30.5	24	1.5	1.5
8	12/30	7.2	30.0	07	-	-
	1/19	-	30.0	25	2.5	2.5
9	12/30	7.0	30.0	12	-	-
	1/19	-	30.0	29	3.0	3.0
10	12/30	6.8	30.0	07	-	-
	1/19	-	29.0	31	3.5	3.5
11	12/30	6.4	30.0	29	-	-
	1/19	-	29.0	31	9.0	9.0
12	12/30	6.5	28.0	32	-	-
	1/19	-	29.0	32	60+	>60.0
13	12/30	-	-	-	-	-
	1/19	-	30.0	28	2.0	2.0

APPENDIX F

PALA LAGOON AND MANGROVE AREA USE SURVEY 1984

This survey is to try and find out how people use the mangrove and Pala Lagoon areas. It is also to try and see what people want to see done with the area in the future.

The results of this survey will be given to the village council so their recommendations can be included in the final report.

Answers in this survey will be confidential. Except for those conducting the survey and those writing the report, no one else will know who answered the questions.

O lenei survey o lo'o taumafai ai e su'esu'eina pe fa'apefea ona fa'aaogaina e tagata le pala. E fia iloaina ai fo'i pe o a ni manatu i le fa'aaogaina o le pala i le lumana'i.

O le a fa'alauiloaina tali o lenei survey i le nu'u ma fa'afesiligiaina ai ni o latou manatu.

O le a le tusiina lou suafa i le survey pe a e le mana'o ai.

PALA LAGOON AND MANGROVE AREA USE SURVEY

Igoa Aso Nu'u
Name _____ Date _____ Village _____
(Optional - Aua le ta'u maia pe a e le man'o ai)

o tagata i le tou aiga Tausaga
in family responding for ____ Age; under 15 ___ 16-25 ___
26-35 ___ 36-55 ___
over 55 ___

1. E fa'apefea ona e fa'aaogaina le pala, ma e fa'afia?
In what ways does your family use the lagoon, and how often?

Ioe Yes	Leai No	Activities	Aso uma Everyday	Fa'afia i le vaiaso times/wk	Fa'afia i le masina times/month
		Swimming-taele			
		Fishing-fagota			
		Crabbing-fai pa'a			
		Clamming- fai tunage			
		Other(specify)			

2. O le a le tele o mea e te maua mai i le pala?
How much does your family catch from the lagoon?

	Taimi nei Now	10 tausaga ua mavae 10 yrs ago	20 tausaga ua mavae 20 yrs ago
I'a i le vaiaso Fish - lbs/week			
Ato Tunage i le masina Clams - baskets/month			
Pa'a i le vaiaso Crabs - week			
Other - specify			

3. A fa'apea ua e silafiaina le ses'esega i le tele o figota, pa'a i'a po'o tunage na maua i aso ua te'a ma taimi nei, o le a le mafuaga ua ala ai ona eseese?
If the above numbers have changed over the years, what do you feel is the reason?

_____
_____
_____

4. O le a le pasene o mea o e maua mai le pala ete fa'atau atu ma le pasene o mea o lo'o fa'aaogaina e la outou aiga?
What percentage of the above is sold and what percentage is for personal use?

Fa'atau atu
Sold _____%

Fa'aoga e le aiga
Personal Use
_____%

5. E te silafiaina pe mata e fia se tupe o lo'o maua mai i le fa'atau atu o i'a p'oo tunage po'o pa'a fo'i, mai le pala i le masina pe o le tausaga?
How much money do you make in a month or year from selling things from the lagoon?
$ _____ per _____

6. E to'a fia nisi o le tou aiga e fagogota i le pala?
How many people in you family use the lagoon for the above activities?

_____

7. O a ituaiga i'a pe o nisi lava mea o lo'o maua mai i le pala?
What kind of fish and other marine life do you catch in the lagoon?

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

8. Fa'asino mai i le fa'afanua le mea e masani ona e fagota ai i le pala.
Indicate on the map/picture where you do most of the activities above.

9. Ta'u mai pe fa'apefea ona fa'aaogaina e le tou aiga le pala, le togo, pe o o vaitafe o lo'o ui atu i tafatafa ane o tou fale.
Indicate which of the following activities your family does around the edge of the lagoon, mangroves or the streams flowing into the lagoon.

_____ Piggery - Fau ai sai pua'a
_____ Dump Rubbish - Tia'i ai lapisi
_____ Land Fill - Tanu
_____ Home Site - Fausia ai fale
_____ Plantation - Toto ai fa'atoaga
_____ Fire Wood - Fai fafie
_____ Sewage Outlet (toilet) - Fa'a alu iai vai mai fale taele, po'o vai o masini ta ofu.
_____ Other - specify

10. E te mana'o ea e fa'aaogaina le pala mo taelega ma fagotaga ma i'a ma nisi lava mea ola o le sami?
Would you like to use the lagoon more often for swimming and catching fish and other marine life?

_____

11. O le a le mea e te manatu e pito i taua? (1-5, tasi e pito i taua, 5 e le le taua tele)
What do you think is the most important? (mark from 1 to 5, with 1 the most important and 5 the least important)

Fagota i le pala
_____ Fishing in the lagoon

Ta ina o le togo ma tanuina o le pala
_____ Cutting the mangrove and filling the land

Ta ina o le togo mo fafie ma fau ai fale
_____ Cutting trees for firewood and for building

Fa'asaina o le fa'aalu o vai le mama i le pala
_____ Stopping the waste pollution in the lagoon

Faasaoina o le toga togo ma fa'asaina le tanuina o le pala
_____ Protecting the mangrove and stopping the fill

12. E te silafiaina o iai ni tulafono a le nu'u pe o le malo fo'i e fa'asaina ai pe pulea ai fo'i au mea e fai i le pala (po'o le fagota po'o le tanuina)? Ta'u mai.
Do you know of any village or ASG regulations that restrict your activity on the lagoon and in the mangroves? Name them.

_____
_____
_____

13. E te silafiaina o le a le mafua'aga o nei tulafono?
What do you feel is the reason for these regulations?

_____
_____

14. A fa'apefea o le tipi ina o le togo ma le le mama o vai o lo'o fa'aalu atu i le toga togo o lo'o a'afia ai i'a, pa'a ma isi mea ola, o le a sou manatu o a mea e tatau ona fai?
If cutting the mangroves and pollution of the lagoon were to kill the fish and clams, what do you feel should be done?

_____
_____

15. O le a sou manatu o a ni mea e tatu ona fia e toe fa'alelei ma toe fa'amama ina ai le pala ina ia mafai pea ona fa'aogaina e a tatou fanau i le lumana'i?

What do you think could be done to improve the condition of the lagoon and the mangroves so you can use the area in the future?

_____

_____

16. Pe mata e te manatu e tatau ona fa'asoina le:
Do you feel ther is a need to protect the:
toga togo
mangrove areas _____

le pala atoa
lagoon areas _____

17. E te silafiaina o iai se so'otaga i le pala, toga ma mea ola o lo'o maua ai. A fai e iai, o le a? (O le a le mea e na'o le pala lava e maua ai tunage ma pa'a ae le maua lava nei mea i isi vaega o Tutuila ma Manu'a?)

Do you think there is a relationship between the mangroves and the fish, clams, and crabs in the lagoon. If yes, what is it?

_____

_____

18. O le a lou manatu o le a se mea e tatau ona fai i le pala ma le toga togo i le lumana'i? (1-5, tasi, e tatau ona faia, 5, le le tatau ona faia)

What do you feel should be done with the lagoon and the mangrove forest in the future? (Rank from 1 the most wanted to 5 the least wanted.)

_____ puipuia uma le pala ma le togatogo
protect all of the lagoon and mangroves

_____ fa'asaoina nisi vaega o le togatogo ma le pala
protect some areas of the mangrove and lagoon

_____ fa'asaoina na'o le pala
protect only the lagoon

_____ fai le mea e matou te manana'o ai
continue as we do now and do what we want

_____ tipi uma i lalo le togo ma tanuina le pala
cut the mangroves and fill in the lagoon area for more land.

19. E tatau ea i le nuu pe o le malo fo'i ona faia ni tulafono e puipuiaina ai le pala ma le togatogo??

Should the village or ASG make regulations to protect the lagoon and forest? What kinds?

_____

20. A fa'apefea o le a faia ni tulafono, o le a le auala sili lava e mafai ona fa'amalosia ai nei tulafono ?
What is the best way to enforce these regulations?

APPENDIX G

SUMMARY OF USE SURVEY DATA

surveys completed - 28

20 families / 127 people average 6.35 people/family

age groups	#	%
< 15	37	29
16-25	39	30
26-35	30	24
36-55	14	11
> 55	7	6
		100

1. In what ways does you family use the lagoon, and how often?

n=20 activity	#families	#days	%of families	Mean#days/yr
swimming	6	396	27	66
fishing	16	1867	73	117
crabbing	14	1532	64	109
clamming	20	2549	91	127

2. How much does you family catch from the lagoon?

n=4	fish	26.25 lbs/week
n=14	clams	4.75 baskets/month
n=10	crabs	9.9 /week

* only two surveys reported catches from the past, both reported higher catches 10 and 20 years ago.

3. If the above number (catch) has changed over the years, what do you feel is the reason?

n=22 reason	#families	%
rubbish	11	50
pollution	6	27
> fishing	2	9
filling/ cutting	2	9
dynamite	1	5

4. What percentage of the above (catch) is sold and what percentage is for personal use.

n=22	sold	32.5%
	pers. use	67.5%
	100% sold	1/22 or 5%
	100% personal	9/22 or 41%

5. How much money do you make in a month or year from selling things from the lagoon?

n=23		65% of the families earned 0$
	range:	$.83/month to $300.00/month
	mean:	$35.83/month/family

6. How many people in your family use the lagoon for the above activities?

3.4 people/family (note earlier 6.4 people/family)

7. Indicate which of the following activities your family does around the lagoon, mangroves or the streams flowing into the lagoon.

n=26	activity	# families	% families
	piggery	5	19
	rubbish dump	5	19
	land fill	7	27
	home site	15	58
	plantation	6	23
	fire wood	21	81
	sewage	1	4
	none	1	4
	not filled out	2	8

10. Would you like to use the lagoon more often for swimming and catching fish and other marine life?

Yes	93%
No	7%

11. What do you think is the most important? (mark from 1 to 5 with 1 the most important and 5 the least important)

	(# families / % families)				
activity	#1	#2	#3	#4	#5
fishing	17/68	3/12	1/4	1/4	3/12
cut&fill	0/0	2/8	3/12	8/32	12/48
fire wood	0/0	5/20	7/28	7/28	6/24
stop pollution	18/69	2/8	3/11	1/4	2/8
protect mangrove	12/46	7/27	4/15	2/8	1/4

12. Do you know of any village or ASG regulations that restrict your activity on the lagoon and in the mangroves? Name them.

	#responses		# responses
no answer	3	no	5
public health	7	no dumping	7
no filling	4	no piggery	1
no mangrove cutting	1	fishing restriction	3
no poison fishing	1	no dynamite fishing	2

13. What do you feel is the reason for these regulations?

	# responses		# responses
no answer	3	preserve for future	7
stop pollution	5	protect environment	3
stop rubbish	3		
health risks	6		
stop outsiders from fishing	2		

14. If cutting the mangroves and pollution of the lagoon were to kill the fish and clams, what do you feel should be done?

stop it	19
inspection & fines	6
ASG & village make laws	2
report violation	1

15. What do you think could be done to improve the condition of the lagoon and the mangroves so you can use the area in the future?

keep it clean	13
support sewer project	7
enforce laws - raise fines(weekly inspect.)	8
help the ASG	2

16. Do you feel there is a need to protect the mangroves and lagoon areas?

Mangroves	yes	24	89%
	no	3	11%
Lagoon Areas	yes	27	100%
	no	0	0%

17. Do you think there is a relationship between the mangroves and the fish, clams, and crabs in the lagoon? If yes what is it?

n=27	protective habitat	22
	food source	12
	no answer	1
	depth of water	1

18. What do you feel should be done with the lagoon and the mangrove forest in the future? (rank from 1 the most wanted to 5 the least wanted)

	(# families / % families)				
	#1	#2	#3	#4	#5
protect all	21/78	3/11	3/11	0/0	0/0
protect some	7/31	11/48	4/17	1/4	0/0
protect lagoon	2/9	2/9	6/26	11/47	2/9
leave as is	1/4	0/0	4/17	12/50	7/29
cut & fill	1/4	1/4	0/0	2/8	20/84

19. Should the village or ASG make regulations to protect the lagoon and forest? What kind?

n=26	Yes	100%
	No	0%

stop pollution	3
stop building near lagoon	2
stop cut and fill	1
more health regulations	1
make fines	1

20. What is the best way to enforce these regulations?

enforce law	2
ASG responsibility	5
ask matais	7
village council	2
create citizen patrol	2
regular inspection	3
make higher fines	6
make another park (people report violations)	1

APPENDIX H

PALA LAGOON AND MANGROVES IN DANGER

Text for slide program-
Slides available at Development and Planning Office-
Office of Coastal Management

1. Pala lagoon is centrally located on the southern coast of Tutuila, American Samoa. It is the only large, nearly enclosed lagoon on Tutuila and is bordered by Nu'uuli, Tafuna and the Pago Pago International Airport.

2. The lagoon is almost one mile in diameter and is a mixture of fresh and salt water. The seawater enters the lagoon through a narrow channel between Coconut Point and the airport. Most of the lagoon is very shallow with depths ranging from 1 to 5 feet depending on the tide. Coconut Point (in picture) forms the eastern boundary of the lagoon.

3. Pala Lagoon is a unique and interesting area of Tutuila and contains many plants and animals not commonly found in the rest of Samoa. This sandbar on Coconut Point is one of the few places on Tutuila where the Cassiopeia jellyfish lives. In American Samoa the puzzlenut tree (le'ile'i) is found around the Pala Lagoon and also on the small island of Aunu'u.

4. Mangrove plants dominate most of the lagoon's shoreline. Mangrove habitats are important spawning and rearing areas for many of Samoa's fish and invertebrates.

5. Here is a thicket of red mangrove (Rhizophora mangle) and stumps of the large oriental mangrove (Bruguiera gymnorhiza). Mangrove trees were once a common feature of stream and river-mouths on Tutuila but many of these mangrove areas have been reduced by cutting and landfilling.

6. This is the shallow northern end of the lagoon bordered by red mangroves and the village of Nu'uuli.

7. During high tide, the roots of the mangrove are actually underwater.

8. The mangrove areas of Pago Pago, Fagatogo, Utulei, and Fagaalu are completely gone now and areas in Aua, Leone, and Fagaitua are greatly reduced.

9. This is a large stand of oriental mangrove trees located on the northern shore of the lagoon. Pala Lagoon has the largest and most important mangrove forest remaining in all of American Samoa.

10. The Papa stream enters the lagoon here and is one of the major sources of freshwater into the lagoon system.

11. Freshwater springs also enter the lagoon from the northern and western shores.

12. The north-western shore has rocky lava outcroppings among the red mangroves.

13. The Vaitele Stream is another principal freshwater system entering Pala Lagoon.

14. Lions Park on the western shore is an important recreation spot for American Samoa and a favorite picnicking destination for many local families.

15. The Airport runway is built over what was once the opening between the lagoon and ocean. Coral and rock was dredged from the southern end of the lagoon to create fill for the runways.

16. The narrow lagoon entrance (ava) is about one third as wide as it was before the runway was built.

17. These are the flowers of the oriental mangrove which will later hold the long, pencil-like seedling.

18. Mangrove seeds begin to sprout while still on the parent plant. Here is a seed that has just fallen and begun to root and grow.

19. This is a young mangrove seedling. You can still see the remains of the seed pod at bottom.

20. These oriental mangrove seedlings have taken root after the larger trees were cut. Mangrove logs are often used for firewood, charcoal, and building materials.

21. Mangrove plants can even grow in the cracks of lava rocks.

22. The mangrove is one of the few plants that can grow in the salty mud of Pala Lagoon. The aerial prop roots have tiny pores that allow the roots to "breathe" air and take in oxygen during every low tide.

23. The tangle of branches and roots which are usually submerged at high tide, trap mud and many different kinds of floating debris which help to protect and reclaim land from the sea. If this mangrove thicket is allowed to grow it will one day become an island and will eventually be a piece of dry land connected to the shore.

24. Here is another picture of the long aerial roots that allow the mangrove to grow in soil constantly saturated by water.

25. Many small runoff streams divide the mangrove forest.

26. Some of the aerial roots can be very long.

27. The larger oriental mangrove has knobby aerial roots that extend far out from the tree.

28. These are referred to as the "knees" of the tree.

29. Here is a mature stand of oriental mangroves in Nu'uuli. These trees reach a height of 45 to 50 feet. They are probably the largest and oldest mangrove trees in American Samoa.

30. Pala Lagoon is home to many different animals. Rock oysters and barnacles are common on intertidal rocks.

31. The mangrove habitat provides a unique and relatively safe environment for many marine organisms. Its unusual root system creates many channels of calm slow moving water and provides food and shelter for these animals

32. Periwinkles are commonly found on the trunks and roots of mangrove trees bordering Pala Lagoon.

33. Clams are abundant in the inner lagoon and are collected for private consumption and commercial sale. If the lagoon were cleaner, more people could collect and enjoy eating Pala Lagoon clams.

34. Land crabs are abundant along the shoreline.....

35 and live in burrows above the high water mark around the lagoon.

36. Fiddler crabs also live in burrows and come out at low tide.

37. Their burrows are below the high water mark and are thus submerged during high tide.

38. The male fiddler crab has one claw which is much larger than the other.

39. The mudskipper is a common and interesting fish that lives in burrows amongst the mangrove roots. They can live in fresh or salt water, breathe air, climb trees, and skip and jump on dry land.

40. The lagoon has a great deal to offer those who wish to fish her waters.

41. These people are using wire mesh traps to catch the large and tasty mangrove crabs.

42 These crabs are trapped and netted for personal use....

43. or for commercial sale.

44. Again, sales would probably be better if the lagoon was cleaned up.

45. Sea cucumbers and clams are also harvested and sold.

46. The lagoon is also used for a trash dump. Garbage is often used as fill to make more land but also pollutes the lagoon.

47. One of the most obvious problems the lagoon faces is litter.

48. Everywhere you look you can see litter which ruins the natural beauty of the area.

49. These are fishing nets and traps on the shoreline of the lagoon. They were probably more common before pollution slowed interest in lagoon fishing.

50. Monofilament gill nets are used to catch crabs (pa'a), mullet (fuafua) and jacks (lupo-ta and malauli).

51. Pala Lagoon is an important nursery and spawning area for many of Samoa's fish and invertebrates. Many types of juvenile fish will find shelter and food among the arched roots of the red mangrove. Rabbitfish (lo), barracuda (sapatu), perch ('ava'ava), and cardinal fish (fo) spend at least part of their life in the lagoon.

52. Throw nets are another popular method of catching fish in the lagoon.

53. Goatfish (i'asina), silversides (sali) and mullet ('anae) are often caught. However.....

54. litter is always present.

55. The streams that flow into the lagoon bring freshwater, and litter.

56. Streams and tides wash wastes from piggeries into the lagoon.

57. Wastes from pigs is a major source of pollution in Pala Lagoon.

58. Sewage and run off from nearby homes and businesses is another major pollution problem facing Pala Lagoon.

59. Here, ground is being cleared for the new sewer line which is scheduled for completion in December of 1985. This is necessary clearing to stop the sewage going into the lagoon. However, clearing in other areas of the lagoon is destroying large areas of the mangrove forest and destroying the animals that live there.

60. Some people enjoy swimming and wading in the lagoon. Most of you will remember the days when people used to enjoy swimming in Pago Harbor, now few do. Will Pala Lagoon be the same in a few years? If it isn't already.

61. Recreational uses of the lagoon would probably increase if pollution were controlled and the litter cleaned up.

62. This is the only lagoon we have. Swimming, boating, and other activities can be a bigger part of it with improvement in the water quality.

63. Lions park is a popular spot for a relaxing picnic.

64. Many people enjoy the park every week, but...

65. too often, litter spoils the place for everyone.

66. Lions park is a great place for the whole family.

67. The Lions Club and other service organizations are making efforts to keep the park clean. It is everyone's responsibility. We all should be helping.

68. Much of the trash floats in from the other side of the lagoon. We have to clean up the whole lagoon in order to keep the park free of litter

69. Spear fishing along the airport and the lagoon entrance can be very productive. Squirrel fish (malau), parrotfish (laia, fuga), wrasses (sugale), butterflyfish (tifitifi), octopus(fe'e) and lobster ('ula) are abundant.

70. The number of fish in this area is directly dependent on the condition of the lagoon. A polluted lagoon would affect fishing in the lagoon as well as the reef areas outside.

71. Mangrove areas within the lagoon are being cut and filled. Along with the waste pollution this is another major problem facing the future of the lagoon.

72. Home building is becoming a major problem as families need new land for their houses. Cutting and filling of the mangrove area are becoming very common. These families are gaining a home but are destroying what could be a long term benefit for everyone, in other words, the lagoon and the animals it supports.

73. Many of you will remember the past when there where more mangroves and fishing was better. The mangroves and better fishing can return if the lagoon is left undisturbed. But...

74 we must remember it takes a very long time for the mangrove to grow.

75. We are loosing the long term benefits of a healthy environment by many of the things we are doing today. In the old

fa'a Samoa, rules and orders given by the village matai's show understanding of this environment and often protected it by banning fishing when fish were spawning. Other rules also protected the fish and the land for the future generations of Samoa.

76. We must remember that the success of today's fishing trip....

77. is directly related to the cleanliness of the lagoon and the condition of the mangrove forest.

78. Pala Lagoon is a beautiful and unique part of this island your village and your home. It plays an important role in your lives and should be treated with respect and care. Its loss would be a loss not only to you but to future generations of American Samoa.

79. Let's work together to make Pala Lagoon a pleasant place to live, fish and relax.

80. The lagoon and mangroves are a very valuable part of your village. We hope you will recognize their value and protect it now and in the future.

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