GUAM

COASTAL MANAGEMENT PROGRAM
TECHNICAL REPORTS

Volume 1

BUREAU of PLANNING
GOVERNMENT of GUAM
AGANA, GUAM

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GUAM COASTAL MANAGEMENT PROGRAM

TECHNICAL REPORTS

VOLUME 1

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FORWARD

The small size of Guam is not an adequate index of the magnitude or complexity of land-use problems and interrelationships. Problems cover the same range as in larger mainland areas. Increasing numbers of people are seeking employment, houses, services and space for recreation and development on Guam. It is clear that if a quality environment and responsible development are included among the goals of a developing territory, care will be required in the allocation of land and water resources. Logic suggests that development should occur in a manner responsible to environmental limitations.

In its approach to balanced land-use planning, the Guam Coastal Management Program has delineated areas of particular concern (APCs). These are areas of ecological, economic, historical or scenic value such that performance guidelines are needed to ensure their responsible development or preservation. Areas of significant hazard such as airport sound and crash zones, floodplains or seismic fault zones are also considered areas of particular concern. The APCs are mapped and described in the Land-Use Plan which provides a basis for the Guam Coastal Management Plan.

Within the Bureau of Planning, the Coastal Management Section has prepared in-house documents which serve to outline basic resources, federal lands and public opinion concerning land and water use. The delineation of APCs has necessitated pioneer efforts to define such activities and areas as power production, aquaculture, coral harvesting and pristine terrestrial ecosystems. Consultants with specific area expertise were contracted to provide studies which serve as the essential base data for delineation of APCs. This volume is comprised of these technical reports and published as a source book, not only for the purposes of the Bureau of Planning, but also as an aid to functional planning divisions within the government and for developers needing specific information for responsible land and water use in their sector.

CONTENTS

ANALYSIS OF RESULTS
CZM LAND-USE OPINION SURVEY

January, 1977

The survey questionaire used for this study was prepared by David A. Bonvouloir. Robert Gomez trained the survey interviewers. Pat Cawunder tabulated the data and Sally Coy assisted in computer programming. Michael Cruz and Pat Cawunder wrote the analysis of results.

Coastal Management Section
Bureau of Planning
Agana, Guam

Preliminary Raw Data Analysis

REGIONAL ATTITUDES CONCERNING COASTAL LAND USE

During January, 1977, the Bureau of Planning and the Bureau of Labor Statistics administered a Land Use Opinion Survey to identify certain local attitudes toward land and water use. A total of 931 residents were surveyed, 776 (83%) from northern districts and 155 (17%) from southern districts. The survey's results are discussed under four major sections: Shoreline Development, Recreational Facilities, Property Ownership, and Citizen Participation.

Shoreline Development

To determine the desireability of certain types of shoreline development to island residents, three questions were asked. The questions and responses are presented in Table 1:

Table 1: Regional Attitudes Concerning Shoreline Development (in percentages)

	North			South			Total		
Questions	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Residential Development should be strictly limited	58	28	14	54	26	20	57	28	15
2. Tourism Development should be strictly limited	46	43	11	46	31	23	46	41	13
3. Business and Industrial Development should be strictly limited	52	36	12	48	35	17	52	36	12

The majority of respondents (57%) feel that residential development should be strictly limited along the coastline. Since 1970, many homes have encroached upon shoreline areas which has severely limited shoreline use by the public. Although there is a slight difference between the north and south in their attitudes toward residential development, the south exhibits a surprisingly high percentage (54%) of respondents who feel that residential development should be strictly limited. Presently, the south is characterized by compact coastal settlements with little room for expansion. Government subdivisions and other government efforts to provide facilities and services in the south have been hampered by existing residential land use patterns. To experience the benefits of government investments in sorely needed road, water, and power systems would entail a certain degree of change in these patterns. However, strictly limiting residential development along the southern coast will alter the traditional living patterns and relationships in the south.

Local opinions lean toward restricting tourism development along the coast. However, the <u>northern</u> region exhibits a stronger tendency to accept coastal resort development than the south. Contrary to expectations, a higher percentage of northerners oppose resort limitations (43 vs. 31). The difference may be attributed to the 23% of the southern sample who have no opinion. Although resort development results in certain benefits, it is also accompanied by numerous costs. Many southerners have not taken a position on this issue.

Generally, residents feel that business and industrial development should be strictly limited along the coastline. Apparently, any development that does not contribute to the environmental qualities of coastal areas would be opposed. Minor regional differences in attitudes exist with the southern residents undecided over the costs and benefits accruing from business and industrial development.

Judging from the responses to the three questions, southern residents appear to be cautious in pursuing future residential, tourist, business, and industrial development in the south. The historic, social, and environmental qualitities have made the south attractive to both island residents and tourists and the benefits of rapid growth as experienced in the north will probably be carefully reviewed by southern residents in the years to come. On the other hand, northern residents are definitely conscious of the negative impacts that have accompanied development. They appear to be against many types of development that may occur along the coast.

Thus far, the Shoreline Protection Act has functioned as the major regulatory mechanism to control coastal development. As shown in Table 2, however, only 7% of the respondents feel that 30 feet is adequate to restrict coastal development and ensure coastal protection. Although 25% feel that 300 feet is an adequate boundary, most respondents feel that more variables should be analyzed prior to delineating a boundary. Presumably, the more appropriate shoreline boundary would not be a uniform designation since it would depend upon the peculiar characteristics of specific geographic areas.

Table 2: Regional Attitudes Concerning the Adequacy of the Shoreline Protection Act (in percentages)

Shoreline Protection Act	North	South	Total
1. 30 feet is enough	6	11	7
2. The distance should depend on things like type of land, existing buildings, or road locations.	40	43	40
3. Should be 300 feet	26	18	25
4. No permit should be required	3	4	4
5. No Opinion	25	24	24

Table 3 compares the response totals of this year to last year's survey. Basically, previous attitudes toward residential development have remained consistent--a majority of respondents feel that residential development should be strictly limited along the coastline. However, a higher percentage of persons in the recent survey feel that tourist and business and industrial development should be strictly limited (see Table 3). Apparently, more residents are beginning to realize that these development should be strictly regulated and that coastal areas should be protected.

Table 3: A Comparison of the 1976 and 1977 Surveys
(in percentages)

	1976 Totals			1977 Totals		
Questions	Yes	No	No Op	Yes	No	No Op
1. Limit Residential Development	59	26	16	57	28	15
2. Limit Tourist Development	38	40	22	46	41	13
3. Limit Business and Industrial Development	57	27	16	62	36	12

Assuming that certain development located near a respondent's home would have a more direct impact on residents, the survey inquired about the desireability of these development. Table 4 presents the responses.

Table 4: Regional Attitudes Concerning the
Location of Specific Land Uses
(in percentages)

	North			South			Total		
Questions	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Object to hotel development near home	49	44	7	39	53	8	47	45	8
2. Object to other Resort Facilities near home	36	58	6	32	61	7	35	58	7
3. Object to a new housing development near home	27	65	8	32	58	10	28	64	8
4. Object to major business establishment near home	30	63	7	31	63	6	30	63	7

It must be emphasized that Table 4 reflects attitudes toward particular projects that may locate near (1/2 mile qualification) a respondent's home and does not necessarily reflect attitudes toward coastal development. In questions 2, 3, and 4 above, the majority of respondents do not object to these developments locating near their homes. This is particularly true in the south. Commerical and residential development would tend to increase property values in adjacent areas as well as increase convenience to nearby shopping facilities.

Whereas supporting tourist facilities can be used by local residents, hotels per se would primarily cater to a transient population. Forty-seven percent of the sample object to hotels locating near homes. The neighborhood character of communities would be destroyed if hotels located there. Northern residents tend to object to hotels locating in proximity to residents more than southern respondents since hotel development has primarily occurred in the north. The prospect of bringing some of the amenities to the south where few facilities exist is enticing to southern residents.

Recreational Facilities

Table 5 aggregates the questions and responses regarding beach access.

Table 5: Regional Attitudes Concerning Beach Access
(in percentages)

	North			South			Total		
Questions	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Public Access should be guaranteed along the coastline	76	12	12	63	12	25	73	13	15
2. Owners of coastal property should be allowed to refuse access to adjacent beaches	30	54	16	23	61	16	29	55	16
3. Have you ever been turned away from private beaches	27	69	3	30	65	5	28	68	4

Our survey indicates that 17% of the southern sample own coastal property whereas only 5% in the north own coastal property. Consequently, we would expect that a higher percentage of southern residents would object to public access. The reverse is true probably because many of the desirable beach areas are located in the south and that more southern residents have been refused access by adjacent property owners. Many northern beaches are inaccessible because of the topographic features of the northern plateau and are less desirable because of the comparatively rougher waters. The probability for owners to refuse access is less in the north. Generally, however, the majority of respondents feel that public access along the coastline should be guaranteed, although beach access through private property to get to the coastline is less desired.

As indicated by the survey, a large majority of respondents feel that Guam lacks sufficient recreational facilities and areas. Also, those that are available are dirty and littered. Table 6 presents the specific responses to recreation-related questions.

The consensus is that Guam lacks recreational facilities and that public funds should be used to upgrade existing facilities. However, when certain facilities cater to particular user groups such as boat owners, respondents are less apt to agree that public funds should be utilized to construct these facilities. Although 86% of the sample indicated that more walking trails and scenic overlooks are necessary, these facilities would probably not be utilized by the local population. This statistic probably reflects the importance of tourism as perceived by the sample population. The frequent media coverage of tourism and proposals to further attract tourists has definitely contributed to this perception.

Table 6: Regional Attitudes Concerning the Quantity and Quality of Recreational Facilities and Areas (in percentages)

Questions	North			South			Total		
	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Are there enough coastal recreational facilities now	19	72	9	14	73	13	18	72	10
2. Have you gone to a beach or park in the past month	62	35	3	72	25	3	64	34	2
3. Should there be more beaches and swimming areas	80	13	7	76	8	16	79	12	9
4. Should there be more parks and picnic areas	89	6	5	88	1	11	89	5	6
5. Should we build more walking trails and scenic overlooks	86	8	6	85	5	10	86	7	7
6. Should the government spend tax money to build marinas and boat launching ramps	48	32	20	43	30	27	47	32	21
7. Are public beaches and shorelines dirty and littered	76	16	8	72	14	14	75	16	9
8. Should military beaches be opened to the public	63	24	13	75	12	13	65	22	13
9. Should the government spend tax money to clean-up public beaches	75	14	11	59	26	15	72	16	12

Table 7 presents the responses to the questions regarding fishing and coral collection. Although more southerners still practice the traditions of fishing, the majority of islanders surveyed do not fish regularly.

Table 7: Regional Attitudes Concerning Fishing and Fish Control (in percentages)

Questions	North			South			Total		
	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Does any member of your household go fishing regularly	29	68	3	51	45	4	32	65	3
2. Should there be laws that restrict fishing and coral collecting	45	42	13	32	58	10	43	45	12

There is little agreement on restricting fishing and coral collecting. Apparently, the fish and coral population are not perceived to be declining and therefore, restrictions are unnecessary at this time. However, this perception can be expected to change if proposals for encouraging the commercial fishing industry were implemented or if Guam succombs to pressures for shoreline development.

Since the survey was administered during the off-season of fishes that are in high demand, the results may not accurately reflect public opinion. A majority of southerners do fish regularly and do not want any type of restrictions place on this practice.

Property Ownership

As indicated in the survey, 65% of the sample feel that property owners should be compensated if affected by government controls. Little regional difference in attitudes is seen between north and south. Apparently, government controls are perceived to have an adverse effect on property owners and are not perceived in the light of an overall public good. Government controls are established to ensure rational development and public health and safety. The consensus on Guam is that these controls take away development rights.

As shown in Table 8, of the 65% of the sample that possess the attitude of compensation for losses incurred by implementing development controls, a clear majority feel that they should be compensated either with money or with land exchange. A slightly higher percentage feel that compensation should be in the form of land exchange indicating the relatively strong values toward land ownership.

Table 8: Regional Attitudes Toward Compensation For Losses Incurred Through Development Controls (in percentages)

Questions	North				South				Total			
	NA*	Yes	No	No Op	NA*	Yes	No	No Op	NA*	Yes	No	No Op
1. Should government pay for losses	28	58	7	7	27	56	7	10	27	58	7	8
2. Should government exchange land for losses	28	59	6	7	27	59	4	10	28	59	6	7

* Those answering "no" on the question relating to compensating property owners are affected by government controls.

Implicit in these questions is the government's ability to compensate property owners with either money or land. In these austere times, the government does not have the financial resources to compensate property owners. It is also questionable whether the government has enough land to compensate these owners. Again, although development controls have been implemented to promote the public welfare, these controls have an impact on individuals. Since the general public is composed of individual citizens, the dilemma of identifying the general public; i.e., who benefits, who does not, and how should these group interests be accommodated increases when the government is confronted with the problem of controlling development.

Citizen Participation Through Public Hearing

The survey posted many questions regarding participation at public hearings. As expected, a large majority (79%) of respondents have not attended a public hearing in the last year. In the south, however, more people have attended public hearings. The smallness of the area, the close personal relationships, and other southern characteristics may contribute to this regional difference.

In general, those that do attend public hearings have found out about them a variety of sources. Of these sources, the newspaper, the commissioner, and friends and relatives are the most common sources of finding out about public hearings.

Public hearings are the most common form of soliciting public responses to development projects. Table 9 presents the responses to some of the reasons for not attending public hearings.

Table 9: Some Reasons for Not Attending Public Hearings (in percentages)

Why Didn't You Attend?	North	South	Total
1. Not Applicable	19	32	21
2. Waste of Time	6	10	7
3. My Opinion Would Not be Used	4	3	3
4. Inconvenient Time	25	25	25
5. Did Not Affect Me Personally	13	13	13
6. Too Technical	2	2	2
7. Other	31	15	29

Although all of the reasons apply to a certain degree, one-fourth of those surveyed felt that public hearings were held at inconvenient times. Table 10 presents responses to the most appropriate time for public hearings.

Table 10: Appropriate Time for Public Hearings (in percentages)

	North			South			Total		
Questions	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Weekday Evenings	48	32	20	40	41	19	46	34	20
2. Weekends	51	31	18	52	28	21	51	30	19

Apparently, the respondents are ambivalent toward holding public hearings on weekday evenings. They generally feel that weekends would be an appropriate time. With all the weekend activities that occur, it is still questionable whether many residents will attend weekend public hearings. Before any proposals for weekend meetings are entertained, the other reasons stated in Table 9 must be studied.

As shown in Table 11, respondents are generally split on the question of whether public hearings provide an appropriate forum to voice opinions. Surprisingly, respondents rule out contact with the commissioner as a viable mechanism to obtain public opinion. In many cases, commissioners are not thought of as knowing exactly what village residents desire. It is generally felt that the size of the village has contributed to the decline in contacts with the commissioners with his constituents, with the northern commissioners suffering most. However, the southern respondents have similar opinions of their commissioner. The rapidly changing, complex of society of today may mean frequent contacts with residents themselves over and above contact with commissioners.

Table 11: Regional Attitudes Toward Participation Mechanisms (in percentages)

	North			South			Total		
Questions	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Do public hearings provide opportunities to voice opinions	38	24	38	35	35	30	37	26	37
2. Does your village commissioner know your opinion	23	65	12	32	59	9	25	64	11

Apparently, most respondents feel that numerous forms of participation should be established and utilized. Table 12 provides these responses.

Table 12: Regional Attitudes Toward Various Participatory Mechanisms (in percentages)

How Should Planners Identify Future Village Needs	North			South			Total		
	Yes	No	No Op	Yes	No	No Op	Yes	No	No Op
1. Ask commissioner	74	18	8	74	12	14	74	17	9
2. Ask church	36	49	15	20	57	23	33	50	17
3. Village meetings	87	4	9	79	6	15	85	5	10
4. Appoint a village representative	67	20	13	56	22	22	65	20	15
5. Ask civic groups	65	19	16	40	37	23	61	22	17
6. Form special advisory committees	73	13	14	50	27	23	70	15	15

As a whole, the respondents to the survey feel that other mechanisms over and above public hearings should be established and utilized. Respondents are ambivalent that public hearings along provide enough opportunities to voice opinions. However, the role of the church in providing guidance and shaping public opinion on contemporary issues is rapidly diminishing.

Conclusions

Many of the results of the survey were expected. Of interest, however, is the frequent "no opinion" response of the southern sample. In nearly every question, southern residents have a greater no opinion response percentage than northern residents. This may indicate the increasing pressure for development that the south is and will be experiencing. The tradeoffs between development and preservation have not been explicit and most southern residents have yet to take a position on this developing situation.

In summary, the survey brought out the following important points:

1. In general, all coastal development should be strictly limited.
2. Along the coastline, public access should be guaranteed although access through private property is less desired.
3. The boundary established by the Shoreline Protection Act in many cases is inadequate to protect Guam's coastline and needs to be re-defined.
4. Recreational areas and facilities are tremendously inadequate.
5. Public taxes should be utilized to maintain and construct only those recreational facilities that cater to a large number of users and not specific user groups.
6. Subsistence fishing is not widely practiced and consequently should not be strictly regulated.
7. Property owners should be compensated for implementing controls that affect the ability of owners to develop their property.
8. Citizen opinions should be obtained through a number of participatory mechanisms.

AN ANALYSIS OF THE INTER-RELATIONSHIPS IN THE COASTAL MANAGEMENT LAND-USE OPINION SURVEY RESULTS

After the straight tabulations of the Coastal Management Land-Use Opinion survey were analyzed, a set of cross-tabulations was done to establish whether there were inter-relationships between age, ethnic group, and other variables and the opinions expressed concerning the government's role in land use. This report contains an analysis of the cross-tabulations.

In all of the opinion questions, there was a fairly high rate of "no opinion" responses (ranging from 6% to 34%, but averaging about 15%). It may be that many of these people did not understand the questions, and would have expressed an opinion if the questions could have been presented in a more meaningful framework.

Table I
Various Characteristics of Different Age Groups
Percent of Age Group:

Age Group	With Ed Level 6th Grade or Lower	With Ed Level 9th Grade or Lower	Who Owned Property	Who Responded "No Opinion" (Average)
16-29	0%	10%	44%	12%
30-44	4%	17%	63%	15%
Older than 44	38%	51%	74%	18%

Table I gives a comparison of educational level, property ownership, and "no opinion" response for the different age groups. Within the last generation there has been a great change in the average educational level of the adult population. The property ownership column shows a significant difference in the percent of age group who own property. All other factors held constant, we would expect the age group, with some property owners, to have fewer "no opinion" responses. As the last column of the table shows, the situation is the reverse. More older people have "no opinion," about those issues, than younger people.

It is the opinion of this analysis that the situation is a result of differences in educational level. If older residents of the community are to have a voice in planning for the island, special attempts will need to gain their input.

In this report, all response to opinion questions are presented as the percentage of respondents who answered yes from those who answered either yes or no. This provides the simplest solution to the problem or people who may well have an opinion but were too polite to tell the interviewer that they did not know the meaning of some of the words in the questions.

Significant Differences

Whenever a question is asked of two different samples of people, some difference between the two answers is expected. If the answers are presented as the percentage of yes responses to yes and no responses, the expected difference depends on the sample size and the percentage itself. If the same questions were repeatedly presented to different samples of a population, 95% of the time the percentage would be written $\pm N$ percent.

in $$N = 2\sqrt{\frac{P(1-P)}{S}}$$

where P = the percent and S = the sample size.

Roughly speaking, a difference of 11 percentage points or more is significantly different. Any smaller difference may be due to random variation and sampling error. This memo only reports significant differences. Attached to this report are copies of the questionnaire with the percentage of yes responses to each opinion questions for each of the ethnic groups, and for different age groups. The reader may wish to examine the pattern of differences in answers to all questions.

Ethnic Differences

In response to the statement "All Development Should Be Allowed," 45% of Filipinos agreed, as did 30% of Guamanians, and 14% of Caucasians. This difference of opinion between ethnic group was one of the greatest in the survey. Generally, Caucasians were the most strongly in favor of strict actions on development. (Residential 80%, tourist 71%, business and industrial 81%.) The majority of Guamanians desired to limit development (residential 59%, tourist 52%, business and industrial 55%), but slightly less than half of the Filipinos sampled wanted limitation on tourist development (45%) and business and industrial development (46%). Interestingly, a healthy majority of Filipino people wanted to limit residential development (70%).

Respondents were asked if they objected to each of the following being built near their home: tourist hotel, other tourist-related business, a new housing development, or a major business or shopping center. The only time the majority of an ethnic group objected to any of the items was the Guamanian population and a tourist hotel. Fifty-seven percent of the Guamanians interviewed would object to a tourist hotel being built near their home. A tourist hotel was the least popular of the items for all ethnic groups (Caucasians 49% object, Filipinos 41%). Generally, fewer Filipinos objected to any of the items than did the other ethnic groups. Guamanians and Filipinos object about equally to residential development as to business and industrial development; but more Caucasians object to business and industrial development (36%) than to a housing development (20%).

There were no significant differences of opinion among ethnic groups concerning shoreline development. A large majority of all ethnic groups believed there should be more coastal recreational facilities, but 91% of Guamanian versus 78% of Filipinos wanted more beaches and swimming areas. People were asked if tax money should be spent to clean up public beaches, and to build marinas and boat launching ramps. Responses are given in Table II.

Table II
Tax Money Should be Used to:

	Clean Up Beaches	Build Marinas
Guamanians	77%	56%
Filipinos	88%	61%
Caucasian	82%	62%
All Other	87%	72%

Clearly, cleaning up beaches is a more popular activity than building marinas. Guamanians are less enthusiastic than the other ethnic groups about spending tax money for either activity. The grouping, all other, which was 15% of the sample, may include more boat owners and thus want tax money to be spent on marinas.

Concerning fishing and shelling, and laws restricting these activities, Guamanians are the most active (40% fish regularly) and Caucasians the least (20% fish regularly). Seventy-six percent of Caucasians are in favor of laws restricting fish and coral collecting, as opposed to 43% Guamanians and Filipinos and 47% of all other ethnic groups. This question produced the greatest divergence of opinion among ethnic groups.

There was a significant difference of opinion among ethnic groups about the best time to hold public hearings. Seventy-five percent of Caucasians favor week-day evenings, while a greater proportion of Filipinos and Guamanians favor weekends. Perhaps two public hearings, one during the week, and the other over the weekend, would allow everyone a chance to participate. Property is owned by significantly more Guamanians than the other ethnic groups (74% as opposed to 56% Filipinos, 37% Caucasians, and 42% other ethnic groups).

Difference of Opinion Among Age Groups

Difference of opinion among age groups are important because they may reflect trends for the future. In response to the question on shoreline development, 49% of young adults believe the distance should depend on characteristics of the area, as opposed to 39% of middle-aged people and 31% of older adults.

Concerning public input to the planning process, 52% of young adults believe public hearings to be adequate, as opposed to 64% of middle-aged people and 59% of the older group. The only other strong difference was in response to the question "should planners ask the church to find out your opinion." Forty-two percent of the older group said yes, but only 25% of young adults wanted the church to represent them. This may reflect a growing independence away from the Spanish tradition of a church dominated society.

Other Inter-Relationships

Other cross-tabulations were done that depict how people answered one question by the way they responded to another. For example, a count was made of people who fish regularly or not by whether there should be laws that restrict fishing. The results showed that 53% of people who do not fish regularly want restrictions on fishing while only 39% of fishermen want such restrictions. Thus there is a reversal of majority opinion between the general population and fishermen. This is the only question for which a reversal of opinion was found. As we might expect, slightly fewer people who own ocean property thought public access should be guaranteed (78% as opposed to 86%). However, the difference does not matter because such a large majority of both groups support public access. Of the 18 possible inter-relationships examined in this way, more than half of them did not show a significant relationship. This is evidence for the overall consistency of responses to the survey, and shows that even people who might have a bias because of a special interest support the common good instead.

AN INVENTORY OF PRESENT AND PROJECTED
COASTAL LAND AND WATER USES
ON GUAM

COASTAL MANAGEMENT SECTION
BUREAU OF PLANNING
GOVERNMENT OF GUAM

By
ALEXANDER C. CHAN

FEB. 1977

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I

INTRODUCTION

Objectives

A major goal of Guam's CZM Land-Use Planning Program is to maintain and improve the quality of the coastal and marine environment; the statutory basis of the CZM Program being the impact of land and water use upon coastal waters.

Even though the entire Island of Guam is considered to be a coastal zone, those present and projected uses adjacent to the seashore obviously have the greatest immediate impact on coastal waters. The objectives of this study are to:

1) Identify Guam's existing and projected coastal land and water uses in a concise format and;
2) establish a base by which the impacts of these uses can be evaluated.

Previous studies have been carried out by various Government of Guam agencies concerning recreational use, parks, fishing, etc. However, a consolidated format has not been designed which takes all present and projected uses into consideration. This report will provide such information.

In the preparation of this study, the researcher interviewed a number of Government of Guam agency officials as well as analyzing all available plans, studies, and environmental impact statements relative to the scope of the project.

Methodology

1) Reviewed the Coastal Survey of Guam (August, 1974 by Richard H. Randall and Jeanne Holloman) for pertinent information. The preliminary information was extracted from Randall's survey in a section entitled "Development and Use Patterns, Culturally Important Areas, and Features." In this study, Guam is divided into twelve sectors on geographical coastal divisions as set forth by Randall (see Figure 1 and Table 1).
2) Set up charts based on Randall's sector divisions and established a list of activities which may occur in any of the sectors.
3) Data collection. The type of data used was obtained from the Bureau of Planning library, personal interviews with Government officials, field work, and information gleaned from private and government publications.
4) Data organization and presentation.

Research Design

The research design follows the basic procedural concept of general to specific. The first section is mainly introductory in nature, while Section II deals with the coastal water categories set up by Guam's Environmental Protection Agency. Section III deals with Guam's existing coastal water uses including sport and commercial fishing, recreation, waste disposal, and miscellaneous. Section IV deals with the existing land uses adjacent to coastal waters. Section V deals with proposed seashore activities explaining each activity both by category and by project.

Table 1

Sector - Locations[a]

Sector	Location
1.	Northeasterly from Pago Bay to Pati Point, then westerly to Tagua Point.
2.	Westerly from Tagua Point to Tarague Channel, then northwesterly to Ritidian Point, and finally southwesterly to Falcona Beach.
3.	Between Hilaan Point and Falcona Beach.
4.	Between Hilaan Point and Fafai Beach.
5.	Between Ypao Point and Fafai Beach (Tumon Bay).
6.	Between Ypao Point and Oka Point (between Tumon and Agana Bays).
7.	Between Oka Point and Cabras Island. (North-facing coastline of the central part of the island).
8.	Includes all of Apra Harbor, the northern coast of Orote Peninsula, Cabras Island, and Glass Breakwater.
9.	Located along the seaward coast of Orote Peninsula, extends from Orote Island southwest to Neye Island.
10.	Between Orote Peninsula and Cocos Barrier Reef (southwest coast of Guam).
11.	Includes the Cocos Barrier Reefs and enclosed Cocos Lagoon, Cocos Island, and the coastal region lying between the mouth of Mamaon and Manell Channels.
12.	Southward from Taogam Point to Manell Channel (southeast coast of Guam).

[a] Note that these sectors and locations are taken from Randall and Holloman's Coastal Survey of Guam.

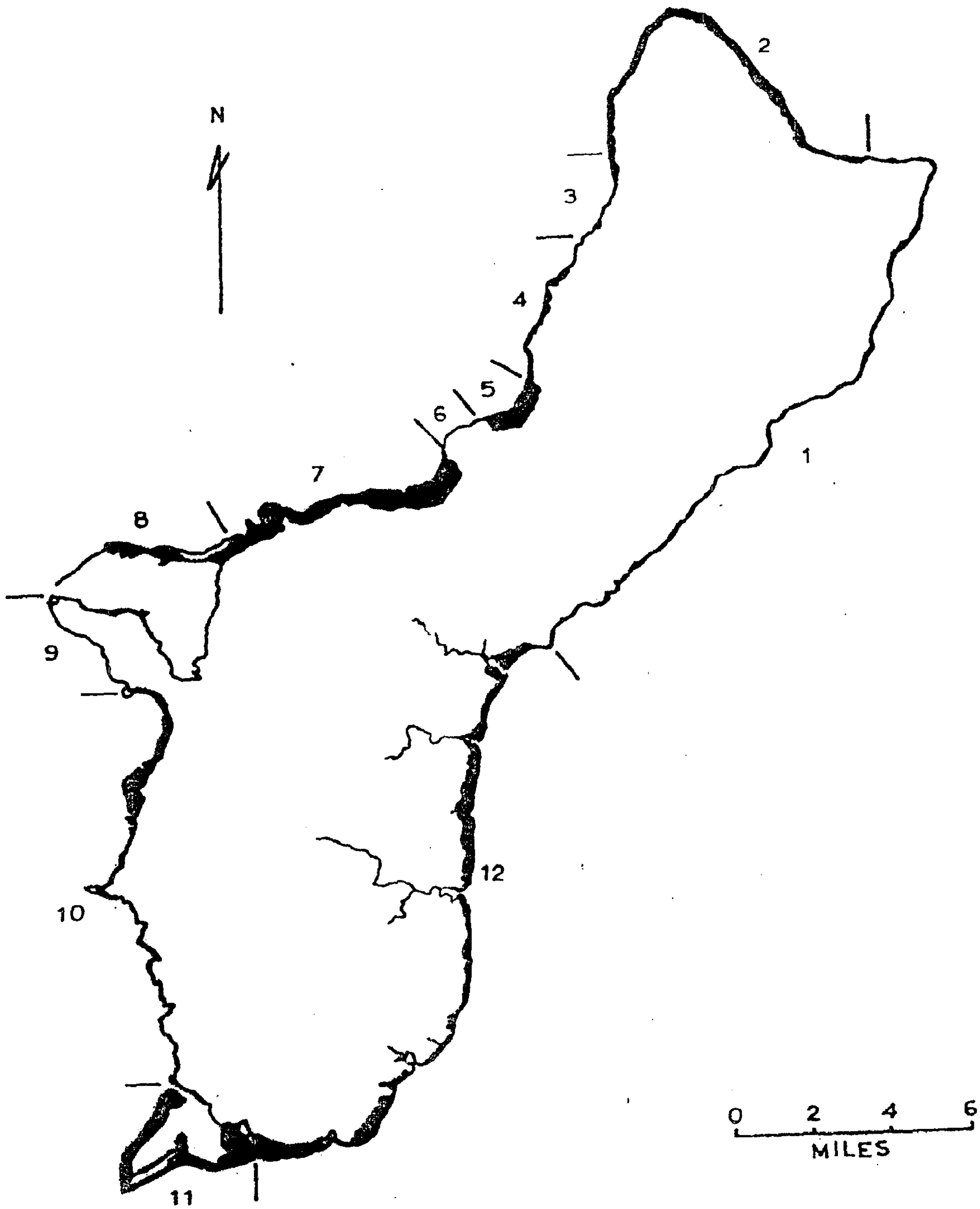

FIGURE 1. Map of Guam showing sector boundaries and fringing and reef flat areas (shaded regions).

Source: Randall and Hollman, Coastal Survey of Guam, University of Guam, Marine Laboratory, Technical Report No. 14, Aug. 1974 P.228

II

COASTAL WATER CATEGORIES

The following are the coastal water categories quoted from the Water Pollution Control Act:

1. <u>Category AA Waters</u>

   The uses to be protected in this category of waters are marine research, propagation of aquatic life (particularly coral reef organisms), conservation of wilderness areas, aesthetic enjoyment, and such recreational activities as do not impair the other established uses. This category of waters shall remain free from pollution attributable to domestic, commercial and industrial discharges or agricultural, construction and other land-use practices that impair their protected use. No pollutant discharges will be permitted therein.

   The categorization of any water area as Category AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

2. <u>Category A Waters</u>

   The uses to be protected in this category of waters are recreation (including swimming, surfing, skin and scuba diving, skiing, and other primary contact sports), aesthetic enjoyment, propagation of aquatic and associated wildlife, commercial, industrial and navigational uses. It is the objective that discharges of any pollutant be controlled to the degree necessary to protect the waters for their specified use.

   Figure 2 shows the categorized coastal waters established by the Government of Guam Environmental Protection Agency. The categorized coastal waters are further divided into sectors based on geographical coastal divisions as set forth in Randall's <u>Coastal Survey of Guam</u>. Coastal water categories based on Randall's sectors are as follows:

Table 2

Existing Coastal Water Uses
Water Categories

GEPA	Sector											
Water Categories	1	2	3	4	5	6	7	8	9	10	11	12
	A+ AA	AA	AA	A+ AA	A	A	A	A	A	A+ AA	A[a]	A+ AA

[a] The Guam Environmental Protection Agency is in the process of trying to reclassify the Cocos Lagoon area from Category A to AA.

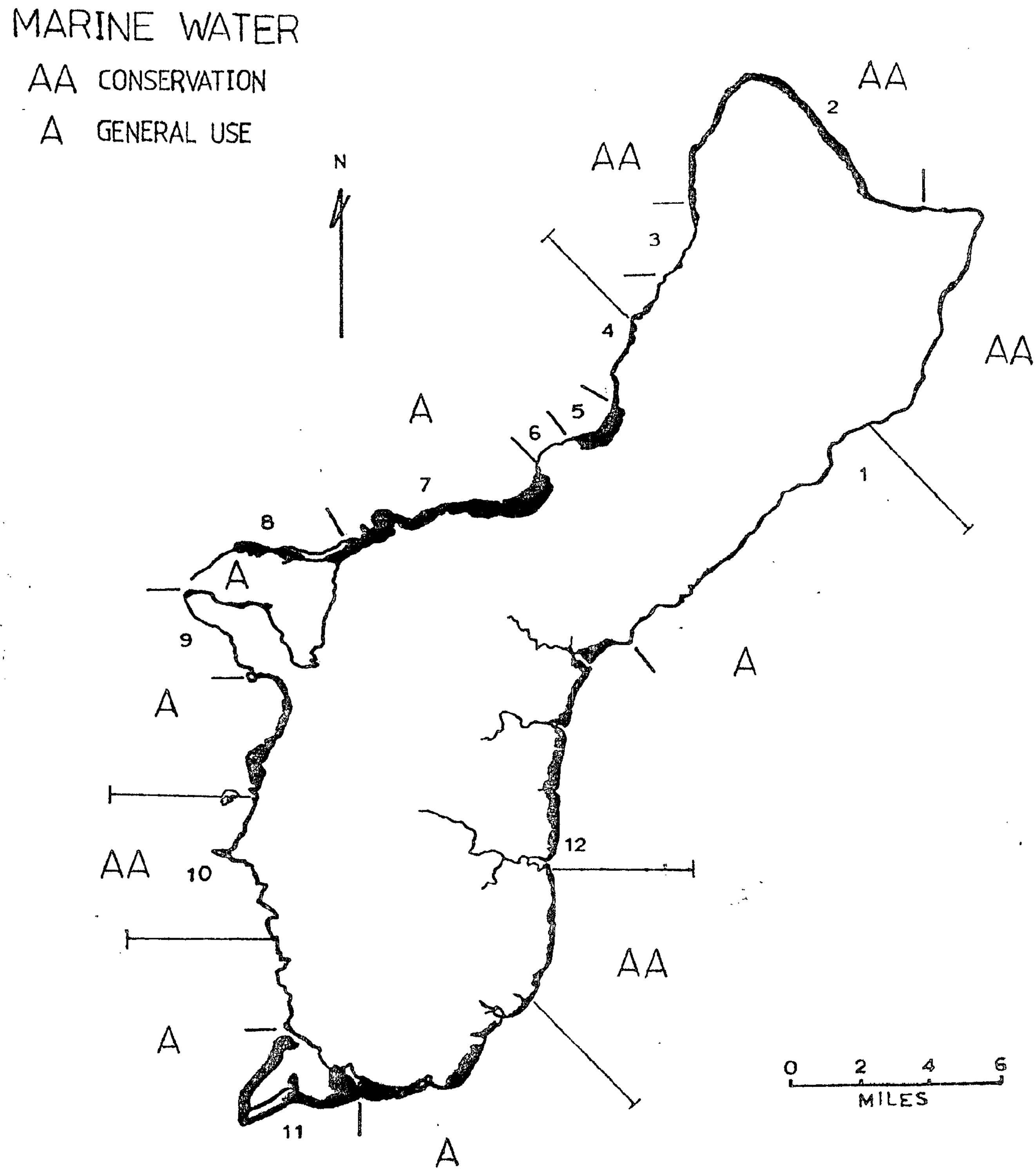

Figure 2. Map of Guam showing coastal water categories as related to the twelve coastal sectors.

III

EXISTING COASTAL WATER USES

One of Guam's major natural resources is the ocean. The marine environment provides potential commercial, educational, recreational, and transportational activities. The ocean is also an ideal place for waste disposal and a variety of other uses. To make better use of this resource under pressure and to focus for future improvements and developments, existing coastal water activities must be examined.

The following existing coastal water uses are divided into sport and commercial fishing, recreation, waster disposal, and miscellaneous. Locations are based on sector divisions (see figure):

Table 3

Existing Coastal Water Uses
Sport and Commercial Fishing

Method	Sector											
	1	2	3	4	5	6	7	8	9	10	11	12
Gill & Net Fishing				X	X		X	X		X	X	X
Throw Net Fishing				X	X		X	X		X	X	X
Fish Traps (gigao)								X			X	X
Spear Fishing	X	X	X	X	X	X	X	X	X	X	X	X
Bottom Fishing	X	X	X	X	X	X	X	X	X	X	X	X
Trolling	X	X	X	X	X	X	X	X	X	X	X	X
Spinning or Hook & Line Fishing			X		X		X	X		X	X	X
Subsistance Reef Gleaning[a]							X	X			X	X
Lobster Fishing	X	X	X	X	X		X	X		X	X	X

[a] Including shell fishing for edible shells, crustaceans, algae, etc.

The researcher was able to review the Job Progress, Guam Fish and Wildlife Investigations, Period Covered: July 1, 1974 - June 30, 1975. The number of fishing activities extracted directly from the progress report area as follows. Figure 3 shows the twelve fishing areas.

Table 4

Results of Twelve Aerial Fisheries Surveys
By Area and Fishing Method

Method	Fishing Areas (Not Coastal Sectors Used in this Inventory)*												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Bottom Fishing (boats)		2		1		5		1	3		1	2	15 bts.
Hook & Line			3	11		2			3	8			27
Spearing	2 bt	1 bt						1 bt					4 bts.
	12	42	16	10		5	2	16		5			108
Gill & Surround Net	13	111	42	21		11	1	6	1	36			241
Throw Net	11	2	3	6		6	2			11			41
Trolling (boats)	22	8	10	5	2	12	6	5	1		1	4	76 bts.
Spinning	4	10	16	30	1	3		2	2	2			70
Unidentified Fishermen	14	13	23	9		11		1	4	10	2	8	95
Boats	3	3	2			8	2	2					20 bts.
bts.	27	14	12	6	2	25	8	9	4		2	6	115 bts.
Total	24	178	103	87	1	38	5	24	10	72	2	8	582

Source: Fish and Wildlife Division, Government of Guam Department of Agriculture, Job Progress Report, Guam Fish and Wildlife Investigations, Period Covered: July 1, 1974 - June 30, 1975.

*See Figure 3 for "sector" delineation used in Fish and Wildlife Division's survey

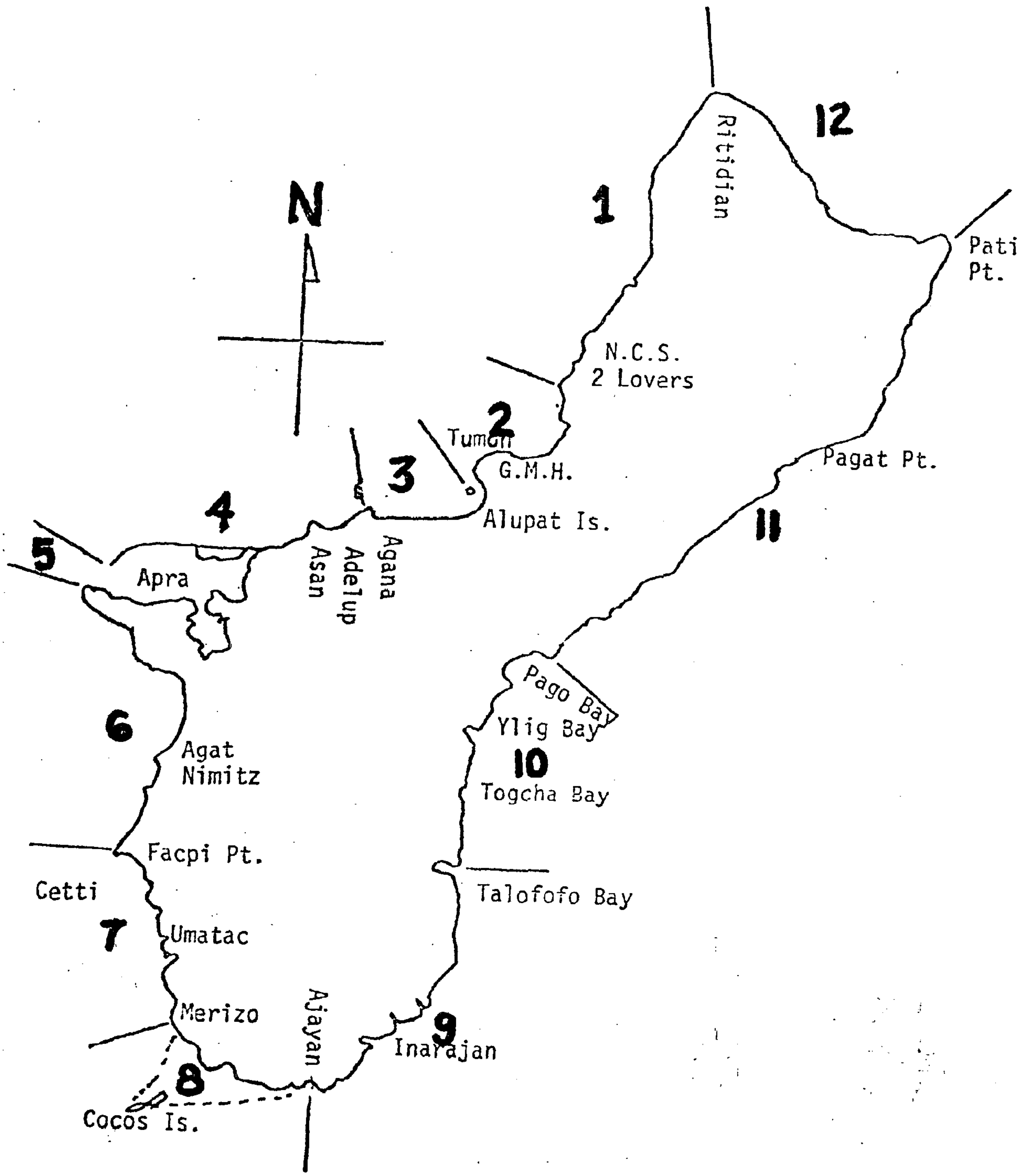

Figure 3 The Island of Guam divided into twelve fishing areas.

Source: Fish and Wildlife Division, Government of Guam Department of Agriculture, Job Progress Report, Guam Fish and Wildlife Investigations, period Covered: July 1, 1974 - June 30, 1975, p. 11.

Table 5

Existing Coastal Water Uses

Recreation

Method	Sector											
	1	2	3	4	5	6	7	8	9	10	11	12
Surfing[1]	X	X	X	X			X	X		X	X	X
Scuba Diving	X	X	X	X	X	X	X	X	X	X	X	X
Skin Diving	X	X	X	X	X		X	X		X	X	X
Snorkeling					X		X	X		X	X	X
Swimming		X		X	X		X	X		X	X	X
Water Skiing								X		X	X	
Power Boating	X	X	X	X	X	X	X	X	X	X	X	X
Sailing	X	X	X	X	X	X	X	X	X	X	X	X
Boat Launching					X		X	X		X	X	X
Boat Anchorages			X				X	X		X	X	
Shell Collecting		X	X	X	X		X	X		X	X	X
Reef Walking					X		X	X		X	X	X

[1] See Table 6 and Figure 4 for site location and description

TABLE 6

RECREATION

SURFING SITES ON GUAM

SECTOR	SITE	LOCATION	DESCRIPTION
1	A	Mangilao	"Underground Cave" private property, body surfing.
1	B	Mangilao	"Marbo caves," small swell
2	A	Yigo	"Castro's Beach," private property, surfing inside reef, very large swell.
3	A	Dededo	"Double Reef," very good rights and lefts, popular.
4	A	Dededo	"Sugans Reef"
4	B	Tamuning	"NCS Beach," small swell.
4	C	Tamuning	"Gun Beach," small swell.
7	A	Tamuning	"Rick's Reef," north swell, ridden frequently.
7	B&C	Agana	"Agana Boat Basin," northwest, most popular all-year-around. Lefts and rights.
7	D	Asan	"Left-Overs" channel, small swell.
7	E	Asan	"Coral Reef," large west swell.
7	F	Piti	"Magoos," large north and west swell.
8	A	Piti	"Magundos," lefts and rights. Best surf on Guam, any swell, very popular.
8	B	Piti	"Spanish Rock," huge swell.
8	C, D & F	Piti	"Disneyland," huge swell.
8	F	Santa Rita	"Gabgab Reef," huge swell.
10	A	Santa Rita-Agat	"Rizal," largest ridable wave on Guam 10'-20'.
10	B	Agat	"Cemeteries," large west swell.

TABLE 6 (CONTINUED)

SECTOR	SITE	LOCATION	DESCRIPTION
10	C	Agat	"Meetings," rights large swell.
10	D	Agat	"Rosey's Island," popular lefts.
10	E	Agat	"Corner Pocket"
10	F	Umatac	"Point Perfection."
10	G	Umatac	"Umatac Bay," very popular west swell.
10	H	Merizo	"Deef Reef."
10	I	Merizo	"Rock-Bottom"
10 & 11	J&A	Merizo	"Merizo," lefts and rights, very popular, good on northwest, west and south swell.
11	B	Merizo	"Beach Side Cocos," small swell.
12	A&B	Merizo	"Mistoe's," very good on east or south swell.
12	C	Inarajan	"Inarajan Bay," large east or south swell.
12	D	Talofofo	"Talofofo Bay," large east swell, beginners only.
12	E&F	Talofofo	"Number 9," small east swell.
12	G	Yona	"YLIG," good on east swell.
12	H	Mangilao	"Marine Lab - Gold Spot." Body surfing, small waves.

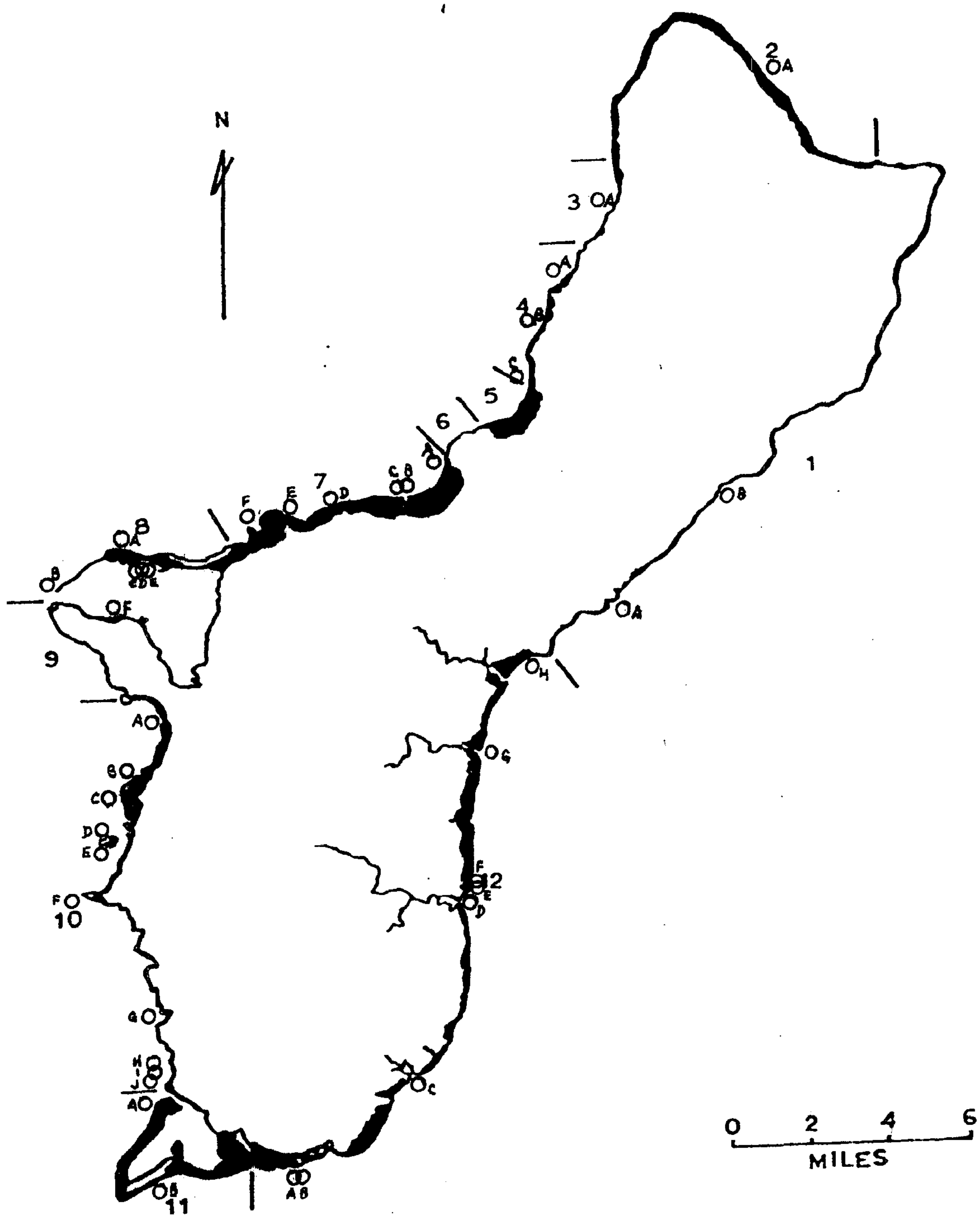

Figure 4. Map of Guam showing surfing sites as related to the twelve coastal sectors, (based on information provided by Guam Surfing Association).

Table 7

Existing Coastal Water Uses
Waste Disposal

Method	Sector											
	1	2	3	4	5	6	7	8	9	10	11	12
Untreated Sewage Outfall	4						1					
Treated Sewage Outfall[a]								1	1	1		2
Thermal Discharges			1[b]				2[c]	2[d]				
Siltation							X	X		X	X	X
Industrial Waste								2				
Agriculture Waste (Experimental Aquaculture)												3
Solid Waste									1			
Storm Drains					8		33			11		6

[a]See Table 8, Figures 5[a] and 5[b] for additional information.

[b]Cooling intake and outfall.

[c]Cooling intake.

[d]Cooling outfall.

Note: 1) Number in the table represents quantity.

Table 8

Sewage Treatment Plants of Guam
(Having an Impact on Coastal Water)

Sector	Location	Name	Treatment	Type
10	Agat	Agat STP-PUAG	Secondary	Activated Sludge
8	Cabras Island[1]	Commercial Port	Secondary	Activated Sludge
12	Pago Bay	Pago Bay Estates Subdivision	Secondary	Commercial Activated Sludge (Aeration)
12	Pago Bay[2]	Yona-Pago Bay, PUAG	Secondary	Commercial Jet Aeration
9	Tipalao Point Santa Rita	Navy STP	Secondary	Activated Sludge

[1]PUAG asking for "after-the-fact" permit. See COE notice, PODCO Notice-01256-S of February 7, 1977.

[2]Scheduled for disconnection. Flow will be diverted to the Agana outfall through Route 4 Interceptor.

Table 9 Point Source Discharges - Coastal Waters Revised Per Field Inspection, GEPA, 1977

IAP IO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
i1	C1	Thermal discharge	Tanguisson Power plant	Philippine Sea	5C-57	56,045 57,515	GEPA, P.O. Box 2977, Agana
i1	C1a	Drainage from Traveling screen 10" RCP pipe	Tanguisson Power plant	Philippine Sea	5C-57	56,030-57,505	Guam Power Authority
i1	C2	Stormwater (constant flow) 1-27" RCP parking lot 2-24" RCP-cooling tower	Okura Hotel	Tumon Bay	5B-55	55,975-55,100	Guam Hotel Okura, P.O. Box 7118, Tamuning
i1	C2a	Stormwater drain and drainage from pool deck	Okura Hotel	Tumon Bay	5B-55	55,980-55,075	Guam Hotel Okura
i1	C2b	Drainage from	Okura Hotel	Tumon Bay	5B-55	55,970-55,075	Guam Hotel Okura
i7	C3	Stormwater, 1-24" RCP-roof top drain and parking lot	Okura Hotel	Tumon Bay	5B-54	55,945-54,955	Guam Hotel Okura

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
47	C4	Stormwater, 1-24" RCP-roof top drain & parking lot	Guam Reef Hotel	Tumon Bay	5B-54 55,875-54,715	Guam Reef Hotel, Box 8258 Tamuning
47	C5	Stormwater (from holding tank 300' above shoreline)	Guam Reef Hotel	Tumon Bay	5B-54 55,910-54,680	Guam Reef Hotel
47	C6	Stormwater and air conditioning effluent, 1-30" RCP pipe	Dai Ichi & Tropricana	Tumon Bay	5B-53 55,155-53,670	Dai Ichi Hotel P.O. Box 3301, Agana
47	C7	Stormwater, 2-8" RCP pipe	Continental Hotel	Tumon Bay	5A-53 54,575-53,465	Guam Continental Hote P.O. Box 2917, Agana
47	C7a	Stormwater from parking lot & platform of Pala Pala	Continental Hotel	Tumon Bya	5A-53 54,515-53,425	Guam Continental Hote
47	C8	Stormwater, 2-30" RCP pipes	Continental Hotel	Tumon Bay	5A-53 54,475-53,405	Guam Continental Hote

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
16	C9	Stormwater,2-24" pipes	Guam Hilton Hotel	Tumon Bay	4F-53	53,845-53,465	Guam Hilton Hotel, P.O. Box GPO, Agana
16	C10	Stormwater, 1-12" RCP pipe 30 ft. above shoreline	Alupang Cove Cond.	Agana Bay	4E-52	52,195-52,325	Alupang Cove Cond. P.O. Box 14-C, Agana
16	C11	Stormwater, 36" RCP, 100 ft. above shoreline	Alupang Cove Cond.	Tumon Bay	4E-52	52,350-52,375	Alupang Cove Cond.
16	C12	Stormwater, long ditch served by two 26" CMP pipes above shoreline	Tamuning Trailer Park Camp Watkins Road Marine Drive	Agana Bay	4E-52	52,55-52,225	Public Works, Gov't. of Guam
16	C12a	Stormwater, two gutter-type drains on each side of apt. bldg.	Lagoon Apts.	Agana Bay	4E-52	52,595-52,200	Ben-Lee, Box 3550 Agana
16	C13	Stormwater, natural ditch (constant flow)	Marine Drive Camp watkins Road	Agana Bay	4E-51	52,515-51,000	Public Works
16	C14	Stormwater, bridge culvert	Marine Drive	Agana Bay	4E-51	52,185-51,090	United Motors Box 3366, Agana

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
6	C14a	Stormwater,2-3" pipes and 1-6" pipe in wall	House	Agana Bay	4E-51	52,135-51,015	United Motors Box 3366, Agana
2	C15	Stormwater, 1-48" RCP with 6 outlet buffer channels	Marine Drive	Agana Bay	4E-50	52,050-50,890	Public Works
2	C16	Stormwater, 2-24" RCP pipes	Marine Drive in front of Guam Dry Cleaners	Agana Bay	4D-50	51,915-50,760	Public Works
2	C17	Stormwater, 1-8" RCP pipe	Marine Drive across Shining Fine Furniture	Agana Bay	4D-50	51,665-50,635	Public Works
2	C18	Stormwater, 2-8" RCP pipes	Marine Drive in front of Shells of Micronesia	Agana Bay	4D-50	51,305-50,515	Public Works
2	C19	Stormwater, 2-8" CMP pipes	Marine Drive back of Saigon Nite Club	Agana Bay	4D-50	51,065-50,465	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
42	C20	Stormwater, 1-12" RCP pipe	Marine Drive	Agana Bay	4D-50	51,045-50,455	Public Works
41	C21	Stormwater, 1-12" RCP, 2-10" pipes, & 2-10" CIP pipes	Marine Drive J & G Motors & Repair Shop	Agana Bay	4C-50	50,835-50,450	J & G Motors, P.O. Box 726, Agana
41	C22	Stormwater, 1-36" RCP pipe Bridge culvert	Marine Drive, beside U. S. Naval Cemetery & Palomo Park	Agana Bay	4C-50	50,670-50,410	Public Works
41	C22a	Sink Drainage, 2" pipe	Open sink	Agana Bay	4C-50	50,575-50,420	Carlos Takano, P.O. Box 611, Agana
41	C23	Stormwater, 24" pipe, almost filled with gravel	Paseo Grounds	Agana Bay	4C-50	50,370-50,375	Public Works
41	C24	Stormwater, 1-24" pipe, filled with gravel	Paseo Grounds	Agana Bay	4C-50	50,360-50,505	Public Works
41	C25	Stormwater	Paseo Grounds	Agana Bay	4C-50	50,085-50,585	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID	COORDINATES	OWNER'S NAME AND ADDRESS
41	C26	Stormwater, 1-24" pipe	Marine Drive Paseo Grounds	Agana Boat Basin	4B-50	49,970-50,465	Public Works
41	C26a	Stormwater, 2-24" RCP pipes	Marine Drive	Agana Boat Basin	4B-50	49,920-50,390	Public Works
41	C26b	Stormwater, 1-24" pipe	Marine Drive	Agana Boat Basin	4B-50	49,905-50,390	Public Works
41	C26c	Sink Drainage	Harbor Patrol sink	Agana Boat Basin	4B-50	49,860-50,450	Department of Public Safety
41	C27	Sewage, raw discharged outside reef 1-36" CIP	Domestic and Industrial Sewage	Agana Bay	4B-51	Agana Outfall	PUAG, P.O. Box 3010 Agana
41	C28	Stormwater, 1-24" RCP pipe	Marine Drive	Agana Bay	4B-50	49,710-50,400	Public Works
41	C29	Stormwater, 1-24" RCP pipe	Marine Drive	Agana Bay	4B-50	49,500-50,415	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
41	C30	Stormwater, 1-16" RCP Pipe	Marine Drive	Agana Bay	4B-50 49,300-50,410	Public Works
41	C31	Stormwater, 1-24" RCP pipe	Marine Drive	Agana Bay	4A-50 48,985-50,455	Public Works
41	C32	Stormwater, 1-24" pipe	Marine Drive	Agana Bay	4A-50 48,745-50,555	Public Works
41	C33	Stormwater, 1-10' pipe	Marine Drive	Agana Bay	4A-50 48,530-50,580	Public Works
41	C34	Stormwater, 3-36" RCP pipes half filled with sand	Marine Drive Ricky's Auto	Agana Bay	4A-50 48,345-50,565	Public Works
10	C35	Stormwater, 1-14" pipe	Marine Drive	Asan Bay	3F-50 47,430-50,510	Public Works
10	C36	Stormwater, 1-14" pipe	Marine Drive	Asan Bay	3F-50 47,214-50,490	Public Works
10	C37	Stormwater, 4'x4' concrete culvert channel half filled with debris	Marine Drive Coral Reef	Asan Bay	3E-50 46,860-50,265	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
40	C38	Stormwater, 1-16" & 1-4" pipes in wall	Haloda Bldg.	Asan Bay	3E-50	46,505-50,080	Jackie Ho See
40	C39	Sewage overflow drains from two holding tanks, no flow	Homes	Asan Bay	3E-50	46,455-50,040	Jack Peters Co., Inc. P.O. Box CR, Agana
40	C40	Leachate, four 4" pipe from backyard	House Lot	Asan Bay	3E-50	46,425-50,035	Francisco T. Rapolla General Delivery, Agana
40	C40a	Stormwater, 6-2" pipes in wall behind residence house lot	House lot	Asan Bay	3E-49	46,315-49,960	Carlos Rojas
40	C40b	Stormwater, 4-8" pipes in wall behind home	House	Asan Bay	3E-49	46,255-49,950	New Century Const. Co.
40	C40c	Stormwater, 1-4" pipe in wall behind home	House	Asan Bay	3E-49	46,210-49,955	Sauget Apartment
40	C40d	Stormwater, 2-24" RCP small flow	Asan Annex	Asan Bay	3D-50	45,540-50,050	Public Works

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
9	C41	Stormwater, 2-24" CMP pipes	Marine Drive	Piti Bay	3C-49	44,775-49,400	Public Works
9	C42	Stormwater, 2-24" RCP plugged with sandand silt deposits	Marine Drive Tepungan	Piti Bay	3C-49	44,605-49,350	Public Works
9	C43	Sewage	Outhouse	Piti Bay	3C-49	44,220-49,220	Jose C. Quenga, P.O. Box 1402, Agana
9	C44	Stormwater, 2-24" RCP pipes	Marine Drive Tepungan	Piti Bay	3C-49	44,095-49,180	Public Works
9	C45	Stormwater, 2-48" RCP pipes 2-12" CIP pipes	Marine Drive Tepungan	Piti Bay	3B-49	43,880-49,110	Public Works
9	C46	Sewage, animal waste	Outhouse, pigpen	Piti Bay	3B-49	43,785-49,110	Tomas Q. Cruz, P.O. Box 433, Agana
9	46a	Washing machine drainage, 1" hose	House	Piti Bay	3B-49	43,750-49,080	Ana Zamora, Box 1987 Agana
9	C47	Stormwater, ditch	Piti Village	Piti Bay	3D-49	43,700-49,055	Public Works

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
9	C47a	Stormwater, 1-8" pipe in wall	USO, Hoover Beach	Piti Bay	3B-48	43,370-48,860	Executive Director, P.O. Box 21, ComNavMar FPO San Fran., 96630
9	C48	Treated Sewage	Commercial Port STP	Philippine Sea	3F-48	41,120-48,835	PUAG
9	C49	Industrial wastewater	GORCO Debal-lasting facility	Philippine Sea	2E-48	40,820-48,995	GORCO, P.O. Box 3190 Agana
9	C50	Thermal discharge	Power Barge Induct.	Outer Apra Harbor	2F-46	41,355-46,895	G. P. A.
4	C51a	Leachate from landfill	Navy Landfill	Rizal Beach	2E-42	40,250-42,585	Navy
4	C50b	2" pipe	Navy	Rizal Beach	2E-42	40,220-42,340	Navy
4	C50c	6" pipe	House	Agat Bay	2E-42	40,420-42,165	Unknown
4	C51	Stormwater, 1-24" pipe	Route 2	Agat Bay	2E-41	40,495-41,750	Public Works
4	C51a	Washwater emptying into stormdrain	House	Agat Bay	2E-41	40,385-41,475	Beatrice Lagasan, Agat

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
4	C52	Stormwater, 3-36" pipes	Route 2	Agat Bay	2E-41 40,400-41,450	Public Works
4	C52a	Stormwater, 1" pipe in wall 2" pipe, sink drainage	House	Agat Bay	2E-41 40,360-41,440	Dionicio Yatar, Agat
4	C52b	Stormwater, 8-4" pipes draining from wall	House	Agat Bay	2E-41 40,355-41,420	Dionicio Yatar, Agat
4	C52c	Sink, washwater drainage, 4" rubber hose draining from wall	House	Agat Bay	2E-41 40,345-41,385	Unknown
4	C52d	Stormwater, 4" pipe draining from wall (also 4" pipe from sand)	House	Agat Bay	2E-41 40,340-41,375	Manuel Babauta, Agat
4	C53	Stormwater, 36" pipe	Route 2	Agat Bay	2E-41 40,350-41,315	Public Works
4	C54	Stormwater, 26" pipe	Route 2	Agat Bay	2E-40 40,210-40,635	Public Works

P).	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
4	C55	Stormwater, open trench	Route 2, Agat Agat Jr. High	Agat Bay	2E-40 40,135-40,525	Public Works
4	C56	Stormwater, 10" pipe	Route 2	Agat Bay	2D-40 39,960-40,490	Public Works
4	C57	Treated sewage	Agat STP	Agat Bay	2D-40 39,470-40,435	PUAG
4	C57a	Sewage	Outhouse	Agat Bay	2D-39 39,530-39,950	Unknown
4	C58	Animal Waste, open sink drain	Pigpen, house	Agat Bay	2D-39 39,530-39,940	Joaquin Atalig, Agat
4	C58a	Sewage	Outhouse	Agat Bay	2D-39 39,520-39,915	Unknown
3	C58b	Sewage	Outhouse	Agat Bay	2D-38 39,300-38,900	Mike Cruz, Agat
3	C59	Stormwater, 36" pipe	Route 2	Agat Bay	2D-38 39,945-39,635	Public Works
3	C60	Stormwater, 36" pipe	Route 2	Agat Bay	2D-38,39,155-38,360	Public Works
3	C61	Stormwater, 36" pipe	Route 2	Agat Bay	2D-38 39,105-38,155	Public Works

AP 0.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
8	C62	Stormwater, 36" pipe	Route 2	Agat Bay	2D-38 39,070-38,030	Public Works
7	C63	Stormwater, 36"	Route 2	Talefac Bay	2C-37 38,785-37-330	Public Works
7	C64	Clear water flowing from 10" pipe	Unknown (may be spring)	Talefac Bay	2C-37 38,750--37,255	Unknown
5	C65	Sewage & animal waste, numerous small drains along shoreline	Houses & animal pens	Umatac Bay	2E-30 40,090-30,695	Umatac village houses along shoreline
5	C65a	Stormwater, 1-2" pipe, 1-16" pipe	Laling's Ham-burger stand	Umatac Bay	2E-30 40,295-30,685	Jose M. Quinata, Umatac
5	C65b	Stormwater, 6" pipe	House	Umatac Bay	2E-30 40,345-30,680	Unknown
5	C65c	Stormwater, 1-36" RCP	Route 4	Toguan Bay	2E-28 40,360-28,835	Public Works
5	C65d	Animal waste, 2" pipe	Animal pen	Amo Creek	2E-28 40,540-28,230	Unknown

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
6	C65e	Animal Waste	Pigpen	Bile Bay	2E-28	40,530-28,210	Unknown
6	C66	Sink drainage	House	Bile Bay	2E-28	40,540-28,140	Unknown
6	C67	Animal waste	Rabbit pens	Bile Bay	2E-27	40,470-27,965	Patty Joe Hoff, Merizo
6	C67a	Stormwater, 1-36" RCP filled with debris	Route 4	Bile Bay	2E-27	40,420-27,865	Public Works
5	C67b	Sewage, sink drainage	Outhouse, sink	Bile Bay	2E-27	40,41027,850	Unknown
5	C67c	Stormwater, 6" pipe in wall	House	Bile Bay	2E-27	40,390-27,825	Claus Fritzen, Merizo
5	C67d	Animal waste	Pigpen	Bile Bay	2E-27	40,450-27,470	Antonio C. Cruz, Merizo
5	C67e	Stormwater, 5-4" pipes, 1-6" pipe in wall	Gas Station	Bile Bay	2E-27	40,475-27,435	Antonio C. Cruz
5	C67f	Stormwater, 1-18" RCP pipe	Route 4	Cocos Lagoon	2E-27	40,535-27,365	Public Works
5	C67g	Stormwater, 1-18" RCP pipe	Route 4	Cocos Lagoon	2E-27	40,620-27,195	Public Works

IAP IO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
6	C68a	Stormwater, sink drainage 6" storm drain	Evergreen Cafe	Cocos Lagoon	2E-27	40,700-27,120	Charles Hambley, Merizo
6	C68b	Sewage, wash-water	Outhouse, washing machine	Cocos Lagoon	2E-27	40,710-27,115	Augustina Mansapit, Merizo
6	C68c	Stormwater, series of small pipes from wall	House	Cocos Lagoon	2E-27	40,890-27,050	Prudencio Meno, Merizo
2	C68d	Stormwater, RCP completely covered with debris	Route 4	Cocos Lagoon	2F-26	41,015-26,970	Public Works
2	C68e	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,085-26,925	Maria Lujan, Merizo
2	C68f	Sewage	Outhouse	Cocos Lagoon	2F-26	41,160-26,875	Unknown
2	C68g	Washwater	Washing Machine	Cocos Lagoon	2F-26	41,180-26,855	Jose Conception, Merizo
2	C68h	Sink drainage	Torres Store	Cocos Lagoon	2F-26	41,200-26,845	Francisca T. Reyes

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
2	C68i	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,210-26,830	Jose C. Barcinas
2	C68j	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,235-26,805	Nicho Laganse, Merizo
2	C68k	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,250-26,800	Tony Enaligo, Merizo
2	C68l	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,270-26,780	Estaban Meno, Merizo
2	C68m	Sewage	Outhouse	Cocos Lagoon	2F-26	41,230-26,730	Isidro Manalisay, Merizo
2	C68n	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,335-26,710	Antonia Cruz
2	C680	Animal waste	Pigpens	Cocos Lagoon	2F-26	41,620-26,580	Unkhown
2	C68p	Sink drainage	Open sink	Cocos Lagoon	2F-26	41,660-26,505	Pete Reyes, Merizo
2	68q	Sink drainage, Washwater	Open sink, washing machine	Cocos Lagoon	2F-26	41,680-26,080	Gregorio Roberto, Merizo
2	C68r	Animal waste	Pigpen	Cocos Lagoon	2F-26	41,720-26,020	Jose Tedpahago, Merizo
2	C68s	Animal waste	Pigpen	Cocos Lagoon	2E-25	41,760-25,970	Unknown

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
)3	C69	Animal waste	Pigpen	Cocos Lagoon	3A-25 42,000-25,720	Merizo Village houses on shoreline
)3	C69a	Stormwater, 1-36" RCP pipe	Route 4	Achang Reef Waters	3B-25 43,820-25,280	Public Works
)3	C69b	Stormwater, 2-36" RCP pipes	Route 4	Achang Reef Waters	3C-25 44,020-25,210	Public Works
)3	C69c	Sewage, sink drainage	Outhouse, open sink	Achang Reef Waters	3C-24 44,580-24,930	Jose Candaso, Merizo
)3	C69d	Leachate	House	Achang Reef Waters	3C-24 44,720-24,910	Maria Reyes Nelson
13	C69e	Stormwater, 2-36" pipes	Route 4	Achang Reef Waters	3C-24 44,820-24,900	Public Works
4	C69f	Stormwater, 1-36" pipe	Route 4	Achang Reef Waters	3D-24 45,510-24,930	Public Works
4	C69g	Stormwater, 1-36" RCP pipe filled with debris	Route 4	Achang Reef Waters	3D-24 45,685-24,970	Public Works
4	C69h	Stormwater, 2-36" pipes 1-18" RCP pipe	Route 4	Achang Reef Waters	3E-25 46,120-25,150	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
04	69i	Stormwater, 3-36" pipes	Route 4	Pacific Ocean	3F-25 47,790-25,500	Public Works
05	C69j	Stormwater, 3-24" pipes	Route 4	Pacific Ocean	4A-26 48,325-26,295	Public Works
05	C69k	Stormwater, 2-24" pipes	Route 4	Pacific Ocean	4A-26 48-580-26,630	Public Works
09	C70	Stormwater, 1-36" pipe	Route 4	Agfayan Bay	4A-27 48,795-27,245	Public Works
09	C71	Stormwater, 1-36" pipe	Route 4	Agfayan Bay	4A-27 48,885-27,270	Public Works
09	C71a	Stormwater, 1-36" pipe	Route 4	Agfayan Bay	4B-27 49,070-27,315	Public Works
09	C71b	Stormwater, 1-36" pipe	Route 4	Pacific Ocean	4B-27 49,235-27,440	Public Works
09	C71c	Stormwater, 1-36" pipe	Route 4	Pacific Ocean	4B-27 49.380-27.545	Public Works
09	C71d	Stormwater, 1-36" pipe	Route 4	Pacific Ocean	4B-27 49.435-27.550	Public Works

AP O.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES		OWNER'S NAME AND ADDRESS
9	C71e	Stormwater, 1-36" pipe	Route 4	Pacific Ocean	4B-27	49,585-27,645	Public Works
9	C72	Sewage overflow, stormwater 1-30" pipe	Inarajan Elem. School & leaching field	Pacific Ocean	4B-27	49,630-27,685	Dept. of Education
9	C73	Sewage, flows in ditch to shore	Several Homes	Inarajan Bay	4B-27	49,800-27,990	Inarajan village houses along shoreline
9	C74	Stormwater, ditch channels to shore	Inarajan, Route 4	Inarajan Bay	4B-27	49,615-28,205	Public Works
9	C75	Sink drainage	Open sink	Inarajan	4B-27	49,820-28,400	Unknown
6	C75a	Leachate, partially exposed leaching field	Talofofo Bay restrooms	Talofofo Bay	4D-34	51,355-34,785	Public Works
2	C75b	Stormwater, 2-10" pipes, several 4" pipes	Jones Beach area	Mana Bay	4E-36	52,200-36,900	Jones & Guerrero Co.
2	C76	Stormwater, 2-36" pipes	Route 4	Pacific Ocean	4D-38	51,900-38,210	Public Works

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
28	C77	Stormwater, air conditioning effluent swimming pool drainage, 2-36" pipes above beach flow to shore	Country Club of the Pacific	Pacific Ocean	4E-29 52,205-39,060	K. Nakajima, Sobbu Guam Dev. Corp., P.O. Box 3123, Agana
35	C78	Stormwater, 1-24" pipe possibly hooked up to STP	Pago Bay Subdivision	Pago Bay	5A-44 54,100-44,660	Public Works
35	C79	Stormwater, 1-18" pipe	Marine Lab, UOG	Pago Bay	5B-44 55,120-44,955	University of Guam
35	C80	Aquarium effluent, 6" pipe	Marine Lab. UOG	Pago Bay	5B-44 55,110-44,945	University of Guam
35	C81	Sewage, flows into rock shelf before entering water, 2-48" RCP culvert goes to cliffline then to ocean	Mangilao-UOG, G.W.H.S. surrounding apts.	Pacific Ocean	5B-44 55,755-44,780	University of Guam
49	C82	Untreated domestic sewage, 18" pipe (average flow-0.4 MGD)	Marbo Housing	Pacific Ocean	6C-51 62,855-51,190	Andersen Air Force Base

MAP NO.	POINT SOURCE NO.	DESCRIPTION	SOURCE	RECEIVING WATER	GRID COORDINATES	OWNER'S NAME AND ADDRESS
62	C83	Untreated domestic sewage, 15" RCP pipe (average flow 1.5 MGD)	Andersen Housing	Pacific Ocean	7E-59 70,225,59,130	Andersen Air Force Base
62	C84	Untreated domestic sewage, 16" RCP pipe (average flow 0.015 MGD)	Andersen Housing	Pacific Ocean	7E-59 70,190-59,840	Andersen Air Force Base
62	C85	Washtack waste-water, 6" RCP pipe (average flow 0.015 MGD)	Air Force Maintenance	Pacific Ocean	7E-60 70,685-60,850	Andersen Aire Force Base

Table 10

Existing Coastal Water Uses
Miscellaneous

Activity	Sector 1	2	3	4	5	6	7	8	9	10	11	12
Dredging					X		X	X				
Landfill							X	X				
Submarine Cables		X		X					X			
Transportation Network[a]							X	X		X	X	
Marine Laboratory												X
Military Reservation	X	X	X	X				X	X	X		

[a]Including piers, marinas, sea terminals, boat ramps, etc.

IV

EXISTING LAND USES ADJACENT TO COASTAL WATERS

Beach areas are a precious resource for Guam, especially in light of the island's tremendous recreational growth along the seashore. The development and improvement of seashore activities lie in the examination of existing land uses adjacent to those coastal waters. It is necessary to evaluate the existing coastal land uses in order to ascertain how each sector is fulfilling it's role in satisfying those activities. It is hoped that in doing so, this will serve as a guide to the future preservation, improvement, or development of our coastal lands in the most beneficial and economical manner. The following depicts the existing land uses adjacent to coastal waters:

Table 11

Existing Land Uses
Adjacent to Coastal Waters

Activity	Sector											
	1	2	3	4	5	6	7	8	9	10	11	12
Agriculture	X	X						X		X		X
Residential			X	X	X	X	X		X	X	X	X
Commercial					X		X	X		X	X	X
Industrial: Fuel Storage								X				
Industrial: Transportation Network[a]							X	X			X	
Industrial: Ammo Wharf								X				
Industrial: Utility Network (Power production)				X				X				

Table 11 (Continued)

Activity	Sector 1	2	3	4	5	6	7	8	9	10	11	12
Industrial: Mining and quarrying	X			X				X				X
Historic and archaeological sites[b]	X	X	X	X	X		X	X		X	X	X
Recreation: Public beaches, parks and reserves		X		X	X		X	X		X		X
Recreation: Camping and picnicking	X	X		X	X		X	X		X	X	X
Recreation: Resorts					X							X
Recreation: Vistas		X		X		X				X	X	X
Wetlands[c]							X	X		X	X	X
Solid Waste Disposal (dump)									X			X
Cemeteries							X	X		X		X
Hospitals						X						
Schools and University							X			X		X
Police and Fire Protection										X		X
Communication and Navigation Facilities		X					X	X	X		X	
Conservation: Forest and Wildlife Preserve	X	X					X			X	X	X
Military Reservation	X	X	X	X				X	X	X		

[a]Including piers, marinas, sea terminals, boat ramps, yacht club, wharves and ship repair facilities.

[b]Figure 5 is a map showing Archaeology Sites of Guam.

[c]Figure 6 is a map showing wetland areas.

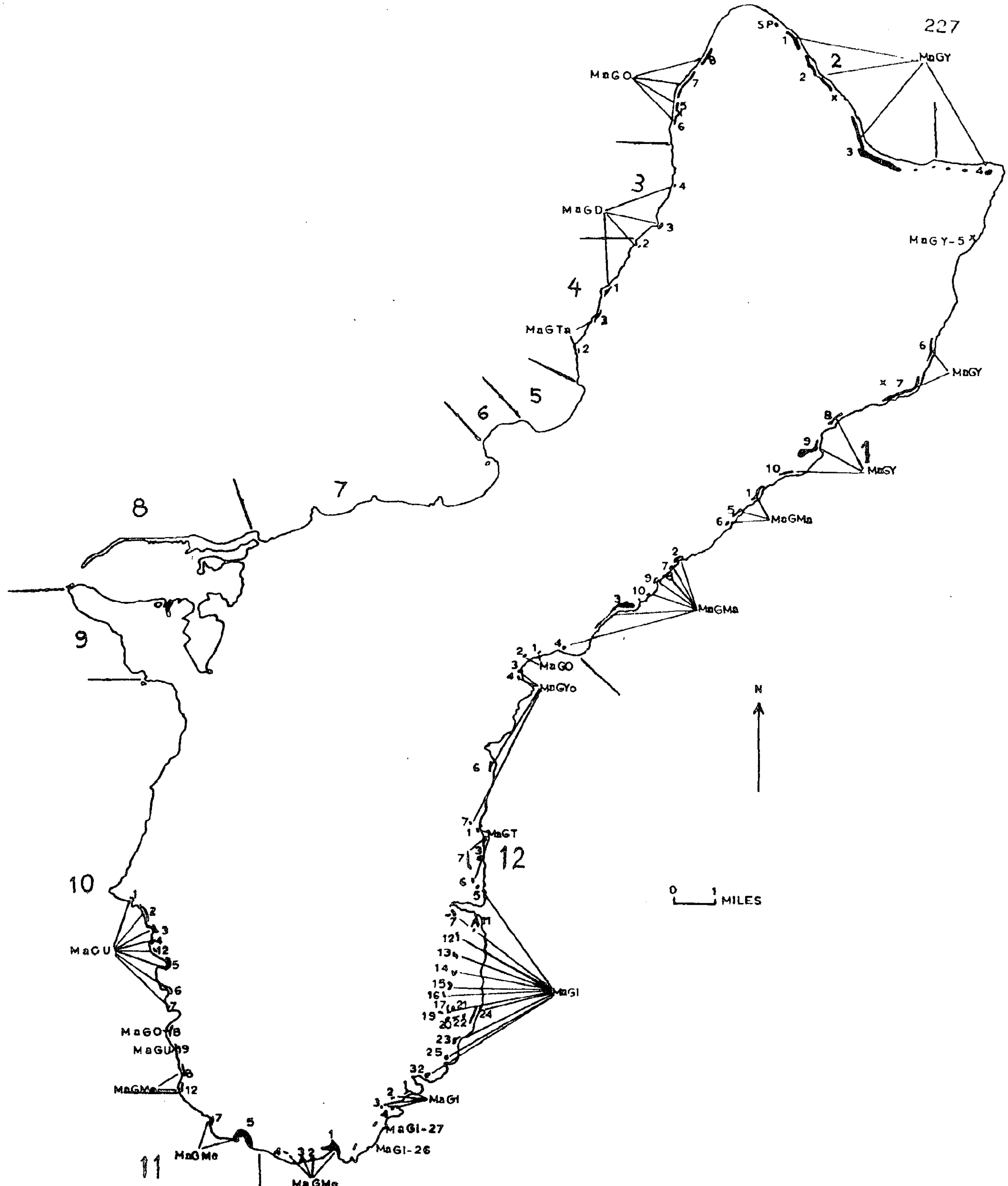

FIGURE 5

Archaeology sites of Guam. Map modified from Reinman (unpublished manuscript).

Source: Randall and Holloman, Coastal Survey of Guam, University of Guam, Marine Laboratory, Technical Report No. 14, August, 1974, P. 227.

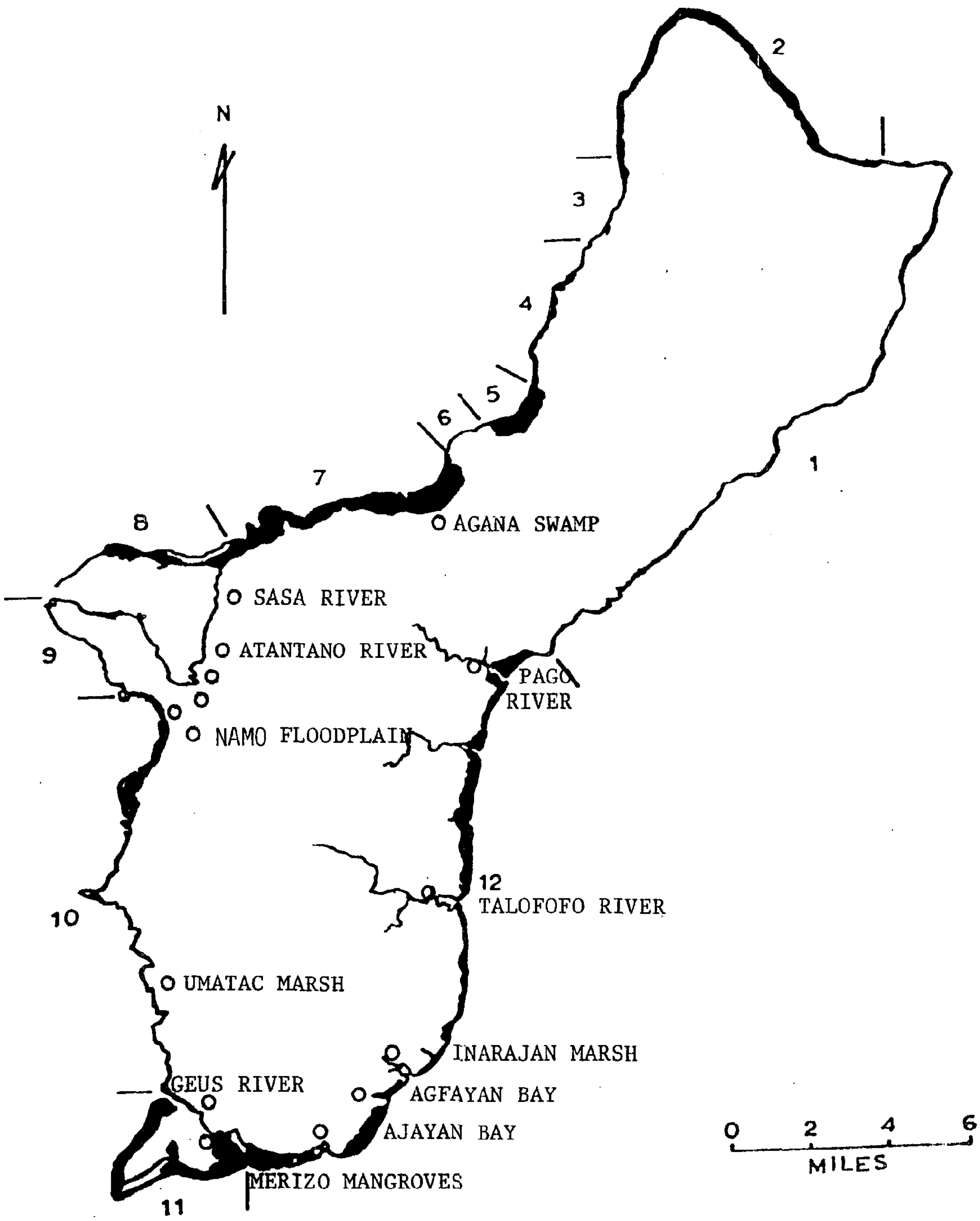

Figure 6 Map of Guam showing wetland areas as related to the twelve coastal sectors.

V

PROPOSED SEASHORE ACTIVITIES

This section serves as a reference to readers who wish to examine the proposed activities to ascertain the implementation value of each activity or project in terms of benefits and economics, as well as social and environmental factors.

The first part of this section presents the reader with a general knowledge of the proposed activities by category. The second part of this section presents the proposed projects (including a general description). Proposed projects may involve more than one type of activity. For example, construction of a marina may involve dredging, landfill, etc. Table 12 is a listing or proposed activities affecting coastal waters. Table 13 is a listing of proposed projects affecting coastal waters.

Table 12

Proposed Activities Affecting Coastal Waters

Activity	Sector											
	1	2	3	4	5	6	7	8	9	10	11	12
Residential	X	X					X					X
Archaeology Sites	X	X										
Agriculture (Experimental Farm)												X
Aquaculture							X	X				X
Urban Renewal							X					
Dredging		X			X		X	X		X	X	X
Landfill		X					X	X		X	X	X
Transportation Network: Marina		X					X	X		X	X	X

Table 12 (Continued)

Activity	Sector 1	2	3	4	5	6	7	8	9	10	11	12
Transportation Network: Harbor Expansion								X				
Transportation Network: Piers		X						X		X	X	
Recreation: Resorts		X			X		X			X		X
Recreation: Swimming Area (Pool)		X			X		X				X	X
Recreation: Artificial Reefs										X		
Recreation: Beaches, beach parks, parks and reserves				X	X		X			X	X	X
Recreation: Picnicking/ Camping		X		X	X		X			X	X	X
Recreation: Beach Access		X		X							X	X
Recreation: Fort										X		
Recreation: Caves	X											
Recreation: Stone Bridge										X		
Recreation: Bell Tower and Conbento (Preservation)											X	
Submarine Cables				X								
Flood Control							X			X		
Waste Disposal: Sewage Treatment Plant and Outfall		X		X			X		X	X		X
Water Line												X
Shore Protection												X

Table 12 (Continued)

Activity	Sector 1	2	3	4	5	6	7	8	9	10	11	12
Sea Water Inlet												X
Thermal Discharge				X				X				
Industrial: Ammo Wharf		X							X			
Storm Drains							X	X				
Industrial: Utility Network (Power production)				X				X		X		

TABLE 13

PROPOSED PROJECTS AFFECTING COASTAL WATERS

SECTOR	ACTIVITY	LOCATION	COMMENT
1	Residential	Sasajyan	Kaiser Housing; roads laid out, no recent development.
1	Archaeological Site	Pagat	Preservation: 1) Access road, parking, ranger's station, shelter and trail. 2) Archaeological investigation and visitors facilities.
1	Recreation: Marbo Caves	Campanaya Point	Located on the cliffs at Campanaya Pt. on the northeast coast. Development.
2	Ammo Wharf	Tarague Channel	Proposed facilities to off load ammo barges from Orote Ammo Wharf.
2	Residential	Uruno Point	Development, high density hotel and condominium.
2	Recreation: Resorts	Uruno Point	Development.
2	Recreation: Swimming Pool	Uruno Beach	Development. Three swimming pools on the reef flat of Uruno Pt. including landfill and dredging.
2	Transp. Network: Marina	Uruno Point	Development including landfill and dredging.
2	Beach Access	Uruno Beach	Access being sought from U.S. Air Force by developer.
2	Waste Disposal: Sewage Treatment Plant and Outfall	Uruno Point	Two plants and one outfall, secondary treated effluent.
4	Submarine Cable	North of Tanguisson Power Plant	Additional cables crossing the reef flat.
4	Recreation: Park	Tanguisson Pt.	Beach development, Hilaan Beach

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
4	Power Plants	Tanguisson Pt.	Future expansion of power plants. Outfall designed for thermal waste.
4	Recreation Park (Two Lovers Pt.)	Harmon Village	Also called Puntan Dos Amantes. Beautification and development (portion completed), restroom, water supply, additional picnic facilities and landscaping. Further development into a regional park serving northern Guam; small camping area, additional picnic facilities, hiking, trails, shelters, and perhaps restaurant, interpretation and landscaping.
4	Waste Disposal: Sewage Treatment Plant and Outfall.	Tanguisson and Hilaan (near NCS)	Sewage system under constr. Centralized wastewater treatment facility with open-ocean disposal of primary treated effluent. Proposed interceptor sewer for the northern link, sewage-pump station and connection from the southern link, the wastewater treatment plant, and the marine outfall for the Northern District Sewerage System also called the Northern Integrated Wastewater System.
5	Transp. Network (Launching Ramps, San Vitores Beach)	Tumon Bay	P.L. 12-127 authorized the appropriation for construction.
5	Recreation Swimming Area (Dredging)	Tumon Bay	Dredging in Tumon Bay and Okura Hotel
5	Recreation: Beach	Matapang Beach Tumon Bay	Development: Small beach park, outdoor recreation facilities, including landscaping, picnic units, restrooms, showers, parking and utilities. Heart of the resort strip along Tumon Bay.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
5	Recreation: Beach	Sirena Beach Tumon Bay, Tamuning	Development: 1) Picnic units, shelters, bathhouse, restrooms and recreation facilities, parking and landscaping.
5	Recreation: Resort	Sirena Beach Tumon Bay, Tamuning	Mandarin Hotel to develop.
5	Recreation: Beach Park	Ipao Beach, Tumon Bay, Tamuning	Beach improvement and development. Beach cleaning, pavilion, renovation park signs, park benches, barbecue-pit repairs, car barriers, open-air theater, restrooms, picnic units, shelters and parking.
7	Transp. Network: Marina	Sleepy Lagoon Tamuning	Small boat basin with dredging and construction of causeway. Status uncertain.
7	Recreation: Resort	Sleepy Lagoon, Tamuning	Hotel Condominium. Status uncertain.
7	Recreation: Park	Padre Palomo Park next to cemetery, East Agana	Improvement: Adding picnic units, park benches, landscaping and enclosing an open-drainage canal.
7	Flood Control	Agana River	Creating levees and channel improvements to control flooding of the Agana River. (COE study).
7	Cultural Center	Agana Swamp	Develop multiple use recreation compatible with the value of the swamp as a unique environmental ecosystem.
7	Recreation: Park	Paseo de Susanna, Agana	Development: Additional parking, shelters and picnic units.
7	Drainage	Camp Watkins, Tamuning	Storm drainage at East Agana Bay. Expansion of existing drainage.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
7	Transp. Network: Road Widening	Marine Drive, Tamuning and East Agana	Widening of road with right-of-way on the beach park area. Elimination of some recreational area.
7	Drainage	East Agana Bay	Storm drains 5 ft. by 18 ft. for runoff from Tamuning.
7	Drainage	San Ramon, Agana	Storm drainage at Agana River.
7	Capitol Buildings	East Agana Bay	Proposed filling of reef flat to build Government buildings.
7	Transp. Network Agana Marina (under construction)	Agana Bay, Agana	Improvement of the existing Boat Basin, expansion and development of a larger marina (including landfill and dredging). The proposed Agana Sewage Treatment Plant is also located in this area. Picnicking area will also be provided. Project is underway.
7	Recreation Picnicking	Agana Marina, Agana	Within the Agana Boat Basin plan.
7	Waste Disposal: Sewage Treatment Plant and Outfall (under construction)	Agana Marina, Agana	Wastewater System - This plant will serve sewers from sewer systems in the center part of the island, including sewer system of Barrigada, NAS, Chalan Pago, Ordot, Yona, Mangilao, Mongmong-Toto-Maite, Tamuning, Asan, Piti, Sinajana, Agana, and Agana Heights which are under construction.
7	Recreation: Beach Park	Agana Beaches, Agana	Development: Two stretches of beach along Marine Drive, including picnic facilities, shelters, restrooms, parking area and landscaping.
7	Urban Renewal	Agana Bay, Agana	Development from Paseo de Susanna to Anigua, including moving businesses from seashore.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
7	Urban Renewal	Asan	Community Development Projects - Acquire lands, improve sites, relocate families and businesses and rehabilitate structures.
7	Recreation: Beach	Piti	Improvement: Drainage improvement, picnic units installation and bench rejuvenation.
7	War in the Pacific Historic Park	Asan Point, Asan	Federal property - National Park service - War in the Pacific National Historical Park, plans completed.
7	Aquaculture: Prawn Hatchery	Asan Point, Asan	Proposed GovGuam hatchery to provide stock for aquaculture of fresh water prawns.
7	Recreation: Beach Park	Piti	Beautification: Upgraded and expanded picnic facilities, beach shelters, drinking fountain, improve landscaping, and fence and rejuvenate beach.
7	Recreation: P.C. Santos Memorial Park	Piti	
8	Aquaculture	Apra Harbor	Good location for aquaculture in Guam at east end of outer Apra Harbor.
8	Industrial Development	Cabras Island	Cannery, factories, etc., proposed after removal of old Ammo Wharf.
8	Port Development	Cabras Island	Expanded port facilities.
8	Transp. Network: Apra Harbor	Apra Harbor, Piti	Harbor expansion, including dredging and landfill. See also Ammo Wharf, Apra Master Plan.
8	Transp. Network: Boat Ramp	Piti Channel	Boat ramp to be built next to Cabras Power Plants for recreational boating.
8	Power Plants	Cabras Island	Additional power plants to be built in 1980's.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
8	Recreation: Marina	Naval Station, Piti	Small boat marina, included in the Commander Naval Force, Marianas Recreation program.
8	Transp. Network: Recreation: Boat Facilities	Apra Harbor	COE study planned for 1977 to determine feasibility of Harbor of Refuge for sailboats and small fishing boats.
8	Agriculture	Naval Shore land Apra Harbor	Navy leasing of coastal lots for agriculture.
9	Ammo Wharf	Orote Point,	Final engineering studies underway for first of three phases, including additional enhance to Apra and Tarague Barge Wharf.
9	Navy Sewage Treatment Plant and Outfall	Tipalao Point, Santa Rita	Near Apra Harbor, upgraded and expanded treatment plant (from primary to Level 1 secondary treatment) and outfall will be repaired. Flows from both military and civilian sources. Agat Treatment Plant will be abandoned. Sewer from Agat-Nimitz Sewer System will go to Navy Treatment Plant but not officially approved.
10	Cement Plant	Southeast of Pagachao Subdivision, Agat	Proposed location for cement manufacturing facility including quarry, crusher, kiln, storage.
10	Transp. Network: Agat Marina	Agat (Gaan Pt.)	Development including dredging and landfill, launching ramp, boat dock and revetment; study being carried out under COE funding.
10	Recreation: Nimitz Beach Park	South of Agat, Agat	Improvement - Parking, beach pavilion, repair barbecue pits, park benches; these are two Japanese anti-aircraft guns, inclusion in the War in the Pacific National Historic Park, questionable at present time.

TABLE 13 (continued)

PROPOSED PROJECTS AFFECTING COASTAL WATERS

SECTOR	ACTIVITY	LOCATION	COMMENT
10	Recreation: Talafac Stone Bridge	Agat	Preservation (restoration development); adjacent site considered a probable area for proposed Agat Boat Basin.
10	Recreation: Talafac Tolai Ancho (Bridge)	Agat near Nimitz Beach	Preservation including repair, stabilization of bridge structure, interpretation and restoration.
10	Super tanker mooring and off loading	Agat Bay	Plan for single paint mooring for super tankers to off load via submerged pipe to GORCO Refinery. Environmental Study Complete.
10	Flood Control	Namo River, Agat	Protect low lands from flooding. (COE Project)
10	Transp. Network: Launching Ramps	Nimitz Beach, Agat	P.L. 12-127 authorized the appropriation for construction. No action at present.
10	Recreation: Artificial Fishing Reef	North of Nimitz Beach, 60 ft. deep	Fish and Wildlife's Division proposes to sink barge as fish habitat.
10	Transp. Network: Launching Ramps	Umatac Bay, Umatac	P.L. 12-127 authorized the appropriation for construction. No action at present.
10	Recreation: Park Bay	Umatac Bay, Umatac	Development and Improvement - Upgrade beach areas, improve picnic areas, parking areas, shelters, picnic units, landscaping/barriers, and Magellan Monument Interpretation. Temporary pier constructed, possible site of a Guam's "Sea Life Park" development by private interests.
10	Recreation: Fort	Umatac Bay, Umatac	Preservation (rest/development), clearing, restoration, walkway, picnic units, parking and interpretation.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
10	Recreation: Fort	Umatac Bay (near entrance, Umatac	Rest/development. Phase I - Archaeological investigation and stabilization. Phase I - Access and parking, trail, interpretation.
10	Recreation: Fort	Umatac Bay, Umatac	Scenic overlook - Development not completed.
10	Sewage Outfall	Umatac Bay, Umatac	Ocean outfall. Dead issue.
10	Treatment Plant With Sewage Outfall	Toguan Bay Umatac/Merizo	Ocean outfall, proposed in initial studies by Gillham, Koebig & Koebig as primary site.
11	Recreation: Bell Bell Tower & Conbento	Merizo	Preservation - Picnic units, shelters, parking, interpretation signs, owned by Catholic Church, federal funds available from Historic Preservation program.
11	Recreation	Cocos Island Merizo	Development - Portion for destination area, boat dock, picnic units, shelters and bath-house-restroom.
11	Recreation: Resort	Cocos Island	Illegal development begun of prior, groin, restaurant by owners. Proposed casino.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
11	Transp. Network: Paradise Pier	Mamoan Channel, Merizo	Proposed private venture; concept approved, no project development to date.
11	Transp. Network: Merizo Pier	Mamoan Channel Merizo	Adjacent access channel, seawall backfill and boat ramp.
11	Transp. Network: Merizo Pier	Mamoan Channel Merizo	Cross-shaped commercial launching pier and mooring facility (accommodate six vessels, Public Notice No. PODCO-01247-3, 9/15/76).
11	Recreation: Merizo Pier Park	Merizo	Development proposed by Government of Guam.
11	Transp. Network: Guam Marine Co. Marina	Adjacent to Cocos Lagoon, Merizo	Temporary boating facility, accommodate four to six 30-foot boats for berthing.
11	Transp. Network: Boat Basin	Achang Bay Channel, Merizo	Dredging and filling at the head of Manell Channel, Merizo to provide small boat launching and berthing facilities while channelizing the creek flow over the reef-flat area.
11	Transp. Network: Merizo Marina and Pier	Geus River Merizo	Boat basin at the mouth of the Geus River. Development - Involved dredging and landfill, including 1) parking area, twenty slip marinas, two launching ramps, water supply, 2) fuel facilities, supply shop, eight picnic units, two shelters, playground, and beach (swimming).
12	Waterline	Inarajan, Merizo	Along the coast.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
12	Recreation: Swimming (Saluglula Pool)	Inarajan	Improvement on parking, picnic units, shelters, renovation of existing facilities, landscaping and camp-site park.
12	Waste Disposal Sewage Treatment Plant and Outfall	Pauliluc Bay Inarajan-Malojloj	Inarajan Sewage System, including a small treatment plant (secondary treated) with an ocean outfall. (See Vol. II, Waste-Water Facilities Plan, p. II-15).
12	Agriculture Experiment Farm	Next to Pauliluc Bay, Inarajan-Merizo	UOG Agriculture Experimental Farm.
12	Aquaculture: Prawn Hatchery	Next to Pauliluc Bay, Inarajan-Merizo	Possible alternate location of Government prawn hatchery.
12	Recreation: Beach	Bebesbes Beach, Inarajan	Development of picnic units, shelters restroom bathhouse, access road, parking area, water supply and power, game area and landscaping.
12	Aquaculture: Commercial Fish Ponds	Agfayan Bay	Eel farming in raised concrete tanks. (under construction)
12	Recreation: Beach	Talofofo Beach, Talofofo	Development.
12	Shore Protection	Talofofo	Riprap protection of the beach and recreation areas and roads at Talofofo.
12	Transp. Network: Bridge	Talofofo River	New road alignment and bridge at river mouth.
12	Recreation: Beach	Ipan Beach Talofofo	Development of Ipan camping area (trail and campsite construction area).
12	Large-scale Recreation Talofofo Waterfall Park	Talofofo River River Valley	Private development.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
12	Reservoir	Ugum River	Hydrological study completed by COE.
12	Recreation: Beach	Tagachang Beach, Yona	Improvement and Development: Initial development and improvement. Phase II-area into regional park serving the east central portion of Guam. Facilities include campsites, group camp area, picnic units, mile trail, outdoor games area, beach conditioning, access road and toilet facilities.
12	Water Treatment Plant	Ylig W.T.P., Yona	This is on the Ylig River; no funds spent. Source of drinking water with filtered waste disposal down stream in river.
12	Transp. Network: Launching Ramps	Pago Bay, Yona	Public Law 12-127 authorized the appropriation for construction.
12	Transp. Network: Launching Ramps	Talofofo Bay, Talofofo	Public Law 12-127 authorized the appropriation for construction.
12	Transp. Network: Launching Ramps	Inarajan Bay, Inarajan	Public Law 12-127 authorized the appropriation for construction.
12	Transp. Network: Launching Ramps	Ylig Bay, Yona	Public Law 12-127 authorized the appropriation for construction.
12	Transp. Network: Ylig Boat Ramp	Ylig Bay, Yona	Development - Launching ramp, parking area and a dock along the shore for transit tie up.
12	Transp. Network: Public Marina and Launching Facility	Ylig Bay, Yona	
12	Recreation: Resort	Ylig Bay, Yona	Hong Kong Land Co., high use condominium resort hotel.

TABLE 13 (Cont'd.)

SECTOR	ACTIVITY	LOCATION	COMMENT
12	Residential	Pago Bay, Yona	Cal-Island Devolopment Co. Residential Housing.
12	Residential	Pago Bay, Yona	Frank Loright Co., Town House type residential housing located on south side of Pago Bay.
12	Educational-Recreational	Marine Lab-UOG Mangilao	Seawater inlet and possible development of aquarium and botanical garden.

Acknowledgments

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A SUMMARY OF MAJOR FEDERAL AGENCY LAND HOLDINGS IN THE TERRITORY OF GUAM

Coastal Management Section
Bureau of Planning
Agana, Guam

January, 1977

I. INTRODUCTION

This report has been developed in response to requirements of Sections 304(a) and 305(b)(1) of the Coastal Zone Management Act of 1972:

304 (a) "Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents."

305(b)(1) "Such management program shall include an identification of the coastal zone boundaries subject to the management program."

Although Federal lands are technically excluded from the provisions of the Coastal Zone Management Act, actions upon these lands judged to have a "spillover" impact upon adjoining areas identified as Guam's coastal zone must be "consistent" with the objectives of the approved territorial CZM Program.

Previous studies have been carried out by the Department of Land Management (GovGuam), and the U.S. Navy concerning an extent of Federal lands. Comparisons of the two reports indicated certain discrepancies which this study attempts to resolve.

A. Objectives

1) To identify federally owned or controlled lands on Guam in order to determine the boundaries of Guam's coastal zone.

2) To provide Federal and local offices an up-to-date summary of Federal land holdings, identifying as accurately as possible supporting data which would be of use in land and water use planning.

3) To establish a mechanism for Federal and local agency review and comment on major CZM products, reports and program development.

B. Organization

This report is divided into four (4) sections as follows:

I. Introduction, Objective, Organization, Methodology, Acknowledgements.

II. Patterns of Federal Land Ownership (Summary Table) 1976.

III. Summary of Major Federal Agency Land Holdings:

This section is the main part of the report indicating:

(1) Map Code: The parcel number of the area appearing on the 1:25,000 scale key map.
(2) Document: Indicates the specific document or drawing from which data was obtained.
(3) Place Name: The name of the installation.
(4) Location: Municipality where place name is located.
(5) Agency Responsible: Indicates what agency controls subject area.
(6) Area: Indicates size of parcel in square meters and acres.
(7) Use: A general description of the area's use.
(8) Grid Number: Indicates general location of area according to Uniform Grid System's grid identifier.
(9) Remarks: As far as possible indicates method of acquisition and changes to the parcel in question subsequent to acquisition.

IV. Appendix: Supporting material used in the preparation of this report.

C. Methodology

Approach to the task included:

1) Research of all pertinent studies, reports and documents in the Bureau of Planning and related local agencies (1 mm).*

2) Extensive interviews with locally-based Federal officials, map compilation (1.5 mm).

3) Draft summary of findings (1 mm).

4) Revision of draft summary for mailing to all Federal offices involved (2 mm).

5) Mailing of pre-final summary to appropriate agencies for comments (1 mm).

6) Revision of pre-final according to comment received (3 mm).

7) Mailing of follow-up letters to agencies not responding within 90 days (05 mm).

8) Final revision and final document preparation (2 mm).

9) Drafting of 1:25,000 map delineating boundaries.

* mm = man months

C. Acknowledgements

The Bureau of Planning's Coastal Management Section would like to thank the now non-operational Navy Real Estate Office for the time and effort required to supply the reproducible maps for the majority of Navy and Air Force Lands on Guam. Special thanks goes to all agencies, Federal and local, that spent the time to review this document for accuracy.

Alexander C. Chan, planner with the Bureau of Planning was responsible for the research in the preparation of this report. David A. Bonvouloir was the program coordinator.

E. Map Note

A map for identified Federal lands has been prepared on the 1:25,000 scale base map mylar reproducible and is available at the Bureau of Planning, 4th floor, PDN Building. Arrangements should be made in advance by contracting the Bureau of Planning, telephone 477-9639/9502 or 472-8711.

II. PATTERNS OF FEDERAL LAND OWNERSHIP (SUMMARY TABLE) 1976

	Agency	Acres	Square Meters	% of Federal Land Held	Estimate % of Total Land Area [2]
A.	Military				
	Air Force	20,,544.54	83,142,605	46.1%	15.1%
	Navy	22,069.24	89,313,021	49.5%	16.3%
	Coast Guard	71.99	291,340	.2%	.05%
	Subtotal:	42,685.77	172,746,966	95.8%	31.45%
B.	Non-Military (Federal)				
	FAA	833.18	3,371,812	1.9%	.6%
	Department of Interior	988.66	4,001,066	2.3%	.7%
	Subtotal:	1,821.84	7,372,878	4.2%	1.3%
	Grand Total (A&B)[3]	~~3,643.68~~ 44,507.61	1,801,198.44	100.%	32.75%

*1 Total areas do not include submerged lands adjacent to property owned by the U.S.

*2 Assuming total acreage approximately 212 square miles x 640 acres/square miles,(calculated with acreage totals).

*3 Differences in conversion factors used account for approximately 5% error in acre/square meter comparison.

III. SUMMARY OF FEDERAL AGENCY LAND HOLDINGS
TERRITORY OF GUAM
JANUARY, 1977

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
1	Y&D DWG # 737254 & 1069486 (RESM)	Ritidian Communication Area (U.S. Naval Facility)	Dededo - Yigo	NAVY
2	Y&D DWG # 597-464	Northwest Guam Air Force Base	Dededo - Yigo	AIR FORCE
3	NAV FAC DWG # 1268476	Tarague natural wells (area #25)	Yigo - Dededo	AIR FORCE
4	NAV FAC DWG # 1268475	Andersen Air Force Base (area #46)	Yigo	AIR FORCE
5A)	NAV FAC DWG # 1268676	Naval Communication Station (R) Finegayan "A"	Dededo	NAVY
B)		"B"	Dededo	NAVY

AREA	USE	GRID NUMBER	REMARKS
1,345,772.04 S.M. 332.546 acres	Terminal equipment building, warehouses, Administration Building, communication antennas and miscellaneous support building.	6L69	1) 602,321.00 S.M. or 148,836 acres acquired by Civil No. 29-62, Y&D DWG #737254. 2) 743,451.04 S.M. or 183.71 acres comprising the 182.4 acres & 1.3 acres of access road within NW Field. Air Force transferred to Navy, classified Ltr. of 3/24/58 (previously under "permit" use).
17,719,143.61 S.M., 4,378.40 acres	Radar installation storage	6L65	Orginal area = 18,462,594.65 S.M. or 4,562.11 acres as shown in Y&D DWG #597-464 later 743,451.04 S.M. or 183.71 acres comprising the 182.4 acres & 1.3 acres of access road within NW Field transferred to Navy under classified Ltr. of 3/24/58.
19,726,401.50 S.M 4,874.39 acres	Fresh Water Source	6R65 7L65	
24,980,350.13 S.M 6,172.64 acres	Housing Administrative Building, Air Field, Commissary, Air Force Headquarter, storage	7L61 7R61	
2,799,123.11 S.M. 691.67555 acres 9,659,925.55 S.M. 2,387.00981 acres 12,459,048.66 S.M 3,078.68536 acres	Antennas field, receiver site, housing areas. Maintenance and Administrative Buildings.	5R61 6L61 5R57 5R61	

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
6	Y&D DWG # 556-711	Aviation Gas, Tank Farm #12	Dededo	AIR FORCE
7	APWO DWG # 11551 & Y&D DWG # 1069308 (RESM)	FAA Site (Naval Radio Station (R) Finegayan)	Dededo	FAA
8	Y&D DWG # 737129 & Y&D DWG # 1,069,308 (RESM)	Air Force Global Communication Station (R) Finegayan Area 16A	Dededo	AIR FORCE
9	Y&D DWG # 1001898	A) Tanguisson Point Power Plant & B) NCS Beach	Dededo	NAVY

AREA	USE	GRID NUMBER	REMARKS
78,317.00 S.M. 19.352 acres	Gas Storage	6L61	
3,198,923.00 S.M. 790.467 acres	Headquarter, primary electronic control station, housing, radio station and air ground and control of navigation.	5R61	1) See Attachment 6 2) U.S. Weather Station in site area=18,564.67 S.M., 4.587 acres (weather station, septic tank, quonset, water value).
3,513,893.00 S.M. 868.283 acres	Communications facility and antennas field, receiver site.	5R57 5R61	(Andersen Communication receiver) transferred Ltr. dated 5/4/60, Navy to Air Force.
A) 108,922.37 S.M. 26.92 acres B) 69,255.01 S.M. 17.1132 acres Total: 178,177.38 S.M. 44.0284 acres	A) Power Plant (joint use) B) Outdoor recreational area	5L57	Original area for Tanguisson Power Plant and NCS Beach is 182,405.55 S.M. or 45.0732 acres (Y&D DWG #1001898). But 1.0448 acres or 4,228.17 S.M. within parcel, transferred to GovGuam (GPA for power for power plant) by deed dated 9/3/70, Dept. of Land Management instrument # 96732. Access and utility R/W to area under permit from Air Force to Navy Beach is now being use by public. See NAV FAC DWG # 127269 for Tanguisson Power Plant increment #2.

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
10	NAV FAC DWG# 1268677	Andersen Air Force Base "A" "B"	Dededo	AIR FORCE AIR FORCE
11	Y&D DWG # 737178	Tumon Maui Well Water Tunnel	Tamuning	AIR FORCE
12	Y&D DWG # 475-750 & MA DWG # 10337	Mt. Barrigada V.H.F. Station site (area #69)	Barrigada	NAVY
13	DOC: 77898 quitclaim deed	Lot No. 7133	Yigo	Dept. of Interior
14		AAFB Sump	Yigo	AIR FORCE
15	DOC: 37496	AACS Radio Range	Dededo	AIR FORCE

AREA	USE	GRID NUMBER	REMARKS
3,321,869.97 S.M 820.8340 acres 512,307.75 S.M. 126.5935 acres Total: 3,834,177.72 S.M 947.4252 acres		5L57 5R57 5R57	Marbo Engineering Depot (part) Marbo Engineering Depot (part)
30,332.00 S.M. 7.4950 acres 14,468.86 S.M. 3.57525 acres 44,800.86 S.M. 11.07039 acres	Water Storage Water Storage	5L53	
3716.12 S.M. .918 acres	VHF Area	5R53	Navy has revocable use permit of area together with access DW Road "G".
185,867.72 S.M. 45.93 acres		6R61	No Survey Data
Negligible		7L61	No Survey Data
92,794.80 S.M. 22.93 acres	Radio Beacon	5R57 6L57	

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
16	Y&D DWG # 683217	Air Force areas "A" "B" "C" (Mt. Santa Rosa)	Yigo	AIR FORCE
17	MA DWG # 10758 10759	Air Force Mt. Santa Rosa Reservoir Site Overflow basin Drain and overflow line Water line R/W	Yigo	AIR FORCE
18A) B) C)	NAV FAC DWG# 1268581	Andersen So. AFB (Marbo Base Command) "A" "B" "C"	Mangilao Dededo Yigo	AIR FORCE

AREA	USE	GRID NUMBER	REMARKS
22,325.00 S.M. 5.52 acres 38,778.00 S.M. 9.58 acres 24,117.72 S.M. 5.96 acres Total: 85,220.72 S.M. 21.06 acres	Long-range radar 2 remote communication air ground facilities. Joint use - FAA. Located in Mount Santa Rosa (Air Force land).	7L57	Access road to area A.B.C. transferred to GovGuam, Ser. 1282, April 8, 1970.
5,205.00 S.M. 1.29 acres 7,186.00 S.M. 1.776 acres 1,728.25 S.M. .427 acres 10,120 S.M. 2.501 acres Total: 24,059.25 S.M. 5.944 acres	Water Storage	7L57	
125,170.85 S.M. 30.9297 acres 8,148,560.38 S.M. 2013.5092 acres 1,598,903.214 S.M 395.0889 acres Total: 9,872,634.44 S.M. 2439.5278 acres	War Dog Cemetery Water Well Andersen Administration Housing Area Water Wells Power Plant Exchange Warehouses	6L53 6L53 6R53 6L53 6R53	

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
19	MA DWG # 10456	Sewer Disposal area. (Former Marbo base command area)	Mangilao	AIR FORCE
20	Y&D DWG # 524-082	Andersen Air Force Base AV Gas Tank Farm	Dededo	AIR FORCE
21	Y&D DWG # 683-257	Harmon Field Quarry	Dededo	AIR FORCE
22	Y&D DWG # 702-230 & Y&D DWG # 1069470	Harmon sink and Pit No. 2	Tamuning	NAVY
23 -	Y&D DWG # 737577	Clear zone runway 24 right. NAS Agana		
1)		Part 1	Barrigada	NAVY
2)		Part 2		
3)		Part 3		

AREA	USE	GRID NUMBER	REMARKS
20126.00 S.M. 4.97313 acres	Sewage Disposal	6L53	Access road to area.
56,914.00 S.M. 14.06 acres	Gas Storage	5R53	Y&D 702181 shows AV Gas fuel system. AAFB to NAS Agana (easement).
93,118.55 S.M. 23.01 acres	Andersen Quarry Annex	5R53	
95,175,00 S.M. 23.518 acres 16,536.00 S.M. 4,086 acres Total: 111,711.00 S.M. 27.604 acres	Storm Drainage System	5L53	1) Document shows storm drainage system from NAS Agana to Harmon sink. 2) Document indicates location of ditches. (Area #2). 3) Navy has perpetual easement (fee) for storm drainages.
- 482,009.00 S.M. 119.107 acres 5,234.00 S.M. 1,293 acres 40,879.00 S.M. 10.101 acres Total: 528,122.00 S.M. 130,501 acres	Air Field	5R53	Parts 1,2, and 3 are fee acquisition. Part 4,5, and 6 are easement acquisition. Part 4 area = 223758.00 S.M. 5.624 acres. Part 5 area = 13,488.00 S.M. 3.333 acres. Part 6 area = 628,079.00 S.M 155.201 acres Y&D DWG #903-195 shows Real Estate requirements for flight clearance.

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
24	NAV FAC DWG# 1268580	Radio Barrigada "A" "B" "C"	Barrigada Mangilao	NAVY
25	NAV FAC DWG# 1268586	Naval Air Station	Barrigada	NAVY
26	MA DWG# 10397 & MA DWG# 6529	Aceorp Maui Well	Tamuning	NAVY
27	Y&D DWG# 1001108	U.S. Coast Guard Section Marianas	Barrigada	U.S. Coast Guard

AREA	USE	GRID NUMBER	REMARKS
8,020,644.93 S.M. 1981.93641 acres 287,351.70 S.M. 71.00588 acres 293,075.11 S.M. 72.42014 acres Total: 8,601,071.83 S.M. 2125.36243 acres	Transmitter station antennas field, Navy Golf Course.	5L49 5R49 6L49	1) 25.36 acres lease USA to RCA for antenna Farm 2) Perpetual easement for off-site drainage system. (USA to GovGuam (NOY(R)-68872) 10.3 acres.
7,087,409.85 S.M. 1751.3299 acres	Two runways operational, Administrative and supply activities. Enlisted men's quarters and related personnel support facilities. BOQ's, officers and enlisted housing and a few miscellaneous operational and personnel support activities. (Civil aircraft utilize the runways jointly with the Navy. (Joint-Use Agreement)	4R49 5L49 5L53	7.5 acre portion of NAS Agana, which is in the process of being transferred to the U.S. Postal Service.
24,179 S.M. 5,97474 acres	Water Storage (inactive)	4R53	Original area 32,996 S.M. (MA DWG#10397), later transferred to GovGuam, Tamuning Telephone Exchange is within this well area.
37,286.54 S.M. 9.2137 acres	Coast Guard Command Facilities Air Detachment area	5L49	

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
28	Y&D DWG# 903-194 & 1069470 (RESM)	Clear Zone runway 6 left.	Mongmong-Toto-Maite	NAVY
29	Y&D DWG# 1118265 LM DWG# 61-67T 29	Navy Cemetery	Agana (Lot 2001)	NAVY
30	Y&D DWG# 737-133 1069330 (RESM)	Global Communication Station (T) Barrigada Area 15@	Barrigada (Mangilao)	AIR FORCE
31	Y&D DWG# 475741	Agana Diesel Electric Generating Plant (Area #35)	Mongmong-Toto-Maite	NAVY
32	Y&D DWG# 458-620 & Y&D DWG# 1103863 (RESM)	Agana Spring (Areas 72)	Sinajana	NAVY

AREA	USE	GRID NUMBER	REMARKS
75,958.00 S.M. 18.769 acres	Air Field Flight clearance zone	4R49	A) Clear Zone fee acquisition area. B) Flight Clearance is easement area. Area = 25,694.00 S.M. 6.349 acres
2,996.00 S.M. 0.740 acres	Cemetery	4L49	
3,000,653.00 S.M. 741.461 acres	Communication facility and antennae field (transmitter site)	5L49 5R49	
24,059.30 S.M. 5.954 acres	Power plant with fence	4R49	2,678 S.M. outgranted to GPA for terminal end of 115KV transmission lines.
108,025.69 S.M. 24.91 acres	Provides area for study of freshwater biology by students.	4L49 4R49	DOC: 117122 license for non-federal use. U.S. Navy lease to Gov Guam, 8/4/72, the entire area outlined on the map by an AS-1 through AS-22 designation is under the auspices of the Guam Science Teachers Assn. In this five-year lease will be up for renewal in 1977.

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
33	HO-D-1427-2	FAA Vortac Site	ASAN	FAA
34	NAV FAC DWG# 1268428	U.S. Naval Hospital (Permanent area # 2)	Agana Heights	NAVY
35	Y&D DWG# 597-762	Incinerator area U.S. Naval Hospital (permanent) (L64-3)	Agana Heights	NAVY
36	Y&D DWG# 475-775 & 1118264 (RESM)	Adelup Reservior area #24	Asan	NAVY
37	NAV FAC DWG# 1322951	Asan Point Housing "A" (North) "B"	Asan	G.S.A.

AREA	USE	GRID NUMBER	REMARKS
226,573.62 sq.ft. 21049.46 S.M. 5.2014 acres	Aeronautical Facilities antennas, minimal requirements to accomplish it function.	3R49	
487044.97 S.M. 120.3509 acres	Hospital and all ancillary activities, family housing.	4L49	
5120.23 S.M. 1.265 acres	Public Works Center, incinerating area.	4L49	
9011.00 S.M. 2.2 acres	Water Storage	3R49	
121748.56 S.M. 0.0846 acres 130746.25 S.M. 32.30797 acres Total: 252494.81 S.M. 62,39257 acres	Leased to Government of Guam Asan Elementary School Medical Storage	3R49	Area A: excessed by Navy to GSA for purpose of leasing (Agreement to use) to Government of Guam (Dept. of Parks and Recreation). For educational and/or Recreation License for one year issued to Government of Guam. Area B: 19 acres (Lot #462) leased for 25 years to Government of Guam for Elementary school site. NOY (R - 68880 remaining areas for medical warehouse.

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
38	DOC: 108908 NAV FAC DWG#	Asan Point Overlook Guam	Asan	Dept. of Interior
39	NAV FAC DWG# 1268478	Nimitz Hill Annes Naval Station (formerly command center) "A" "B" "C" "D"	Asan	NAVY
40				
41	Navy's long term lease expired June 30, 1975.			
42	Y&D DWG# 458-686	Sasa Valley Tank Farm (Area #26)	Piti	NAVY

AREA	USE	GRID NUMBER	REMARKS
66,588.22 S.M. 16.4542 acre	Site for War in the Pacific National Historical Park.	3R49	Transferred from Navy 8/4/70. Being a portion of the U.S. Naval Hospital Annex, Asan Point (Area "A") comprising portion of Lot Nos. 436, 437 & 438.
220,158.36 S.M. 54.4021 acres 1,806,911.06 S.M. 446.4956 acres 989,981.72 S.M. 244.6288 acres 1,882.35 S.M. .4650 acres 3,018,933.49 S.M. 745.9915 acres	Public Works, contains family housing. NAVSTA used for administration, community/recreational, bachelor housing purposes. COMNAVMAR Headquarters	3R29	
-			
1,428,860.49 S.M. 358.078 acres	Water Storage	3L45 3L49	Reference - MA DWG# 10002

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
43	NAV FAC DWG# 1323321 1323322	Apra Harbor Reser-vation		
		"A"	Santa Rita	NAVY
		"B"	Piti	NAVY
		"C"	Piti	NAVY
		"D"	Piti	NAVY
		"E"	Piti (Cabras Island)	NAVY
		"F"	Piti - Santa Rita	NAVY

AREA	USE	GRID NUMBER	REMARKS
3142.58 S.M. 0.7765 acre		2R41	
3585265.34 S.M. 885.9348 acres	Black Oil Storage	3L45	
23615.63 S.M. 5.8355 acres		3L49	1) 5 acres required for use in connection with Piti Power Plant 2) See Y&D 702-166 proposed cutback Apra Harbor Reservation
22108.33 S.M. 5.4631 acres	USO Beach - Recreational area-parking, quarters, basketball court, general storage, dressing room, diving platform, rain shelter, etc.	3L49	APOW DWG# 11372 Hoover Park USO area-15,000 S.M. 3.7 acres Navy to Gov't of Guam - Piti Power Plant site. License for non-federal use of real property DOC: 92658 from January 70 to December 70. 800 sq. ft. of land. (to above rt. 11 and new power plant cooling channel-Cabras Island)
847,092.00 S.M. 209.3201 acres	Commercial and industrial (Mobil petroleum storage) (sewage treatment plant).	3L49	35 ± acres out granted (Lease License Permits) to Mobil, U.S. Lines, Matson Lines and United Seamans Service for industrial purpose
19,000,726.95 S.M 4694.915 acres Total: 23481950.83 S.M. 5802.2455 acres	Command areas, harbor facilities, wharves, supply depots, housing areas, barracks, F.O. tank farms, power plant recreational beaches and parks	2L45	Original area is 19,258,027.14 S.M. or 4758.4955 acres. 257,300.19 S.M. or 63.58 acres transferred to GovGuam by deed dated 3/29/76 (DOC: 268358) 1) for (GPA) Cabras Island Power Plant- (33.33 acres) and; 2) GPA fuel tank farm (30.25 acres).

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
44	Y&D DWG# 1015410	U.S. Coast Guard Loran Station	Santa Rita	U.S. Coast Guard
45	Y&D DWG# 1015409	U.S. Coast Guard Buoy Depot	Santa Rita	U.S. Coast Guard
46	NAV FAC DWG# 1268582	Apra Heights Housing "A" "B"	Santa Rita	NAVY
47	NAV FAC DWG# 1268583	Naval Magazine "A" "B"	Santa Rita Agat-Santa Rita	NAVY

AREA	USE	GRID NUMBER	REMARKS
201,641.0. S.M. 49,8264 acres		2L45	
52,412.49 S.M. 12.9514 acres (Parcel 1)		2R45	Parcel 1 is a transfer (U.S. Coast Guard) Parcel 2 is license to use (1964). Area: 3,188.95 S.M. 0.7880 acres Additional area of 0.97 acres adjacent to Parcel 1, license to use (1976 to 1981)
51,106.93 S.M. 12.6287 acres 865,349.91 S. M. 213,8318 acres Total: 916,456.84 S.M. 226.4605 acres	Housing Area	2R41 3L41	
- 859,085.11 S.M. 212.2837 acres 24,634,500.86 S.M. 6087.2928 acres Total: 25,493,585.97 S.M. 6299.5765 acres	Ammunition Storage PWC water treatment and water storage PWC Housing, NAVMAG Administration (Fena Valley Reservoir)	3141 3R41 3L37 3R37	30 ± acres within "A" leased to GovGuam for Agat-Santa Rita School (NOY (R)-68869, dated 9/15/74 for 25 years)

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
48	Y&D DWG# 475-773	C.A.A. Site (area #90)	Yona	F.A.A.
49	Y&D DWG# 458-654	Fena Valley watershed area #22	Agat Talofofo	NAVY
50	Y&D DWG# 475716	(Former U.S. Coast Guard Loran Station Cocos Island area #29 NAVSTA Recreation area, Cocos Island)	Merizo	NAVY USCG LORAN Station Cocos Island transferred to Navy in 1966.
51	Y&D DWG# 1015408	NASA Apollo Tracking Station. Dandan area	Inarajan	Private lease to NASA
52	DOC: 115867 Quit claim deed	Lot # 259	Piti	Dept. of Interior
53	DOC: 115867 Quit claim deed	Lot # 260	Piti	Dept. of Interior
54	DOC: 115867	Mt. Tenjo	Piti	Dept. of Interior

AREA	USE	GRID NUMBER	REMARKS
151839.04 S.M. 37.52	Low frequency radar aeronuatical facilities Mineral requirement to accomplish its function	4L41	
3581498.73. S.M. 885.004 acres	Fena Valley Reservoir & watershed area.	2R33 3L33	
87.817.14 S.M. 21.70 acres	Picnic, swimming snorkeling, scuba diving, fishing	2L25	Under no-cost (5year) License to Government of Guam from U.S. Navy NOY (R)-68893 April 1975-1980
13319553.16 S.M. 3291.3201 acres	Apollo tracking station acess road, collimation tower, cable easement, etc.	4L33	Parcels 1,2,3,4,6, of Dandan Estate Lot "B"
354678.00 S.M. 87.6 acres	War in the Pacific National Historic Park	3R49	LM DWG# E4-70T 668 & 9
40317.00 S.M. 9.96 acres	War in the Pacific National Historic Park	3R49	LM DWG# E4-70T 668 & 9
809374.60 S.M. 200 acres	War in the Pacific National Historic Park	3L45 3R45	LM DWG# E4-70T 668 & 9

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
55	DOC: 115867 Quit claim deed	194-2-1	Agat	Dept. of Interior
56	DOC: 108908 Land transfer	Nimitz Beach	Agat	Dept. of Interior
57	DOC: 108908 Land transfer PWC DWG#12440 Y&D DWG# 1118110 Ltr. of transfer dated 5/27/63 SECNAV TO SECINT	Pedro C. Santos Memorial Park (Hoover Park)	Piti	Dept. of
58	DOC: 108908 Land transfer Y&D DWG# 1069075 (RESM)	Asan Point Tank Farm	Asan	Dept. of Interior
59	DOC: 94353 Quit claim deed	443 Part 2	Agat	Dept. of Interior

AREA	USE	GRID NUMBER	REMARKS
13,293.67 S.M. 3.3 acres	War in the Pacific National Historic Park (Recreational area beach)	2L37 2R37	LM DWG# E4-70T 668 & 9
48,523.33 S.M. 11.99033 acres	Inclusion in the war in the Pacific National Park. Recreational area - boating facilities, camping, picnic, scuba diving, swimming, snorkeling	2L37 2R37	1) Y&D DWG #458-612 2) Parks and Recreation of GovGuam indicate Interior owned only 7 acres
25,793.20 S.M. 6.3736 acres	Basketball, parking snorkeling and swimming	3L49	1) Also called Bill Daniel Park (part of Hoover Park) 2) Y&D DWG #857-448 proposed cut back for Apra Harbor Reservation excess property area 13,109.00 S.M. 3.239 acres
167,378.67 S.M. 41.36 acres		3R49	Transfer from Navy 5/27/63 LM DWG #E4-70T 699
12,900 sq.ft. 1,199.29 S.M. .296 acres	War in the Pacific National Historic Park Recreational area, beach activities.	2L37 2R37	LM DWG #E4-70t 699

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
60	DOC: 94353 Quit claim deed	443 Part 1-R4	Agat	Dept. of Interior
61	DOC: 94353 Quit claim deed	446	Agat Santa Rita	Dept. of Interior
62	DOC: 94353 Quit claim deed	499 (Asan Ridge Battle Area)	Asan	Dept. of Interior
63	DOC: 94353 Quit claim deed	497-1 (Asan Ridge Battle Area)	Asan	Dept. of Interior
64	DOC: 115867	497R-1 (Asan Ridge Area)	Asan	Dept. of Interior
65	DOC: 108908	Apra Harbor Reserva-ion (situated at the Intersection North-east of Rt. #1 and Rt. #6).	Piti	Dept. of Interior

AREA	USE	GRID NUMBER	REMARKS
293,807 sq.ft. 27,295.67 S.M. 6.745 acres	War in the Pacific National Historic Park No activities in this area.	2L37 2R37	Part of Agat- Sumay Memorial Park. LM DWG #E4-70T 699
639,056.12 S.M. 157.9 acres	War in the Pacific National Historic Park	2L37 2R37	LM DWG #E4-70T 669 Part of Mt. Alifan Battle site (national parks service).
1,181,529.97 S.M. 291.96 acres	War in the Pacific National Historic Park	3R49	LM DWG #E4-70T 688 letter from Interior indicates they own area of 297.3 acres
205,328.00 S.M. 50.7 acres	War in the Pacific National Historic Park	3R49	LM DWG #E4-70T 668
170,064.51 S.M. 42 acres	War in the Pacific National Historic Park	3R49	
64,778.00 S.M. 16.008 acres		3L49	1) Y&D DWG #702-166 proposed transfer to GovGuam. 2) NAV FAC #132332 GovGuam, Dept of Education. 3) DOC: 108908 Land transfer from Secretary of Defense to Interior.

MAP CODE	DOCUMENT	PLACE NAME	LOCATION	AGENCY RESPONSIBLE
66	Public Law 93-435; 88 Stat. - 1210 NAV FAC DWG# 7009862	All submerged lands adjacent to property owned by the U.S. Above the line mean high tide.	Adjacent to property owned by the U.S.	U.S.

AREA	USE	GRID NUMBER	REMARKS
			For more detail please refer to public law. Presential Proclamation 4347 of 2/1/75, reserved to USA and placed under the administration jurisdiction of the Navy: a) Submerged lands of inner outer Apra Harbor b) Submerged lands in the vicinity of Jinapsan Beach and Uruno Point.

APPENDIX 1: CONVERSION FACTORS USED FOR THIS REPORT

CONVERSION FACTORS

Linear - Area

L I N E A R

UNITS	CENTIMETERS	METERS	KILOMETERS	INCHES	FEET	MILES
Centimeter	1	0.01	0.00001	0.39370	0.032808	0.5/062137
Meter	100	1	0.001	39.37	3.28083	0.3/062137
Kilometer	100000	1000	1	39370.00	3280.83	0.62137
Inch	2.54	0.0254	0.4/0254	1	0.083333	0.4/0157828
Foot	30.4801	0.304801	0.3/0304801	12	1	0.3/0189394
Miles	160934.72	1609.3472	1.60935	63360	5280	1

A R E A

UNITS	SQUARE INCHES	SQUARE FEET	ACRES	SQUARE MILES	SQUARE METERS	HECTARES
Square Inches	1	0.006944	0.6/0159423	0.9/02491	0.3/06451626	0.7/064516
Square Feet	144	1	0.4/0229568	0.7/0358701	0.092034	0.5/0929034
Square Acres	6272640	43560	1	0.0015625	4046.873	0.404687
Square Miles	4014489600	27878400	640	1	2589998	258.9998
Square Meters	1549.9969	10.76387	0.3/0247104	0.6/03861006	1	0.0001
Hectares	15499969	1076387	2.47104	0.00386101	10000	1

Notations like 5/0, 6/0 etc. are to be replaced by ciphers, e.g., 0.0000062137

1 Land Square = 9.652525 Square Miles
1 Land Square Unit = 250,000 Square Meters = 61.776 Acres = 2,690,962.5 Square Feet
1 Land Square Unit = 25 Hectares
1 Land Section = 6,250,000 Square Meters = 625 Hectares = 1,544.4 Acres
1 Land Square = 25,000,000 Square Meters = 2500 Hectares = 6,177.6 Acres

FUTURE POWER PRODUCTION AND TRANSMISSION
ALTERNATIVE PLANS
GUAM, USA

Prepared For

Coastal Management Section
Bureau of Planning
Agana, Guam

By

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June, 1977

F O R E W O R D

The contents of this report are primarily centered around existing and future progressive expansion of facilities that will be needed to produce energy for the people of Guam and the military establishments. Included are progressions developed to show (1) optimized capability of new plant as needed to supply future power demand (2) annual projected increase in estimated KWH generation (3) corresponding fuel oil needs (4) pass thru of fuel oil cost to consumers and (5) fuel oil refinery capability on Guam and other facets related to power production and future projection.

I N D E X

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I. Maps and drawings of power related facilities

a. NAVFAC Drawing No. 7.900.500. This drawing gives the location of the Navy owned and operated Piti power plant and adjacent fuel oil storage tanks. The building housing the steam turbine-generators is numbered "4910". It contains 3 x 11,500 KW De Laval turbine-generators and 2 x 22,000 KW Allis-Chalmers turbine-generators. All units are in serviceable condition except one of the De Laval 11,500 KW units, which is beyond economical repair.

b. Drawing No. 70-38-3 is the boundary survey of the Cabras steam power plant before site development was undertaken.

Drawing No. 1001-5 is the plot plan of the Cabras steam power plant.

The above mentioned facility consists of 2 x 66,000 KW, 1800 psig, 1000/1000 deg F reheat steam turbine-generators. The site development included accommodations for installation of 2 future turbine-generators of equal or approximately 50% greater capacity. The Cabras steam power plant is wholly owned and operated by the Guam Power Authority.

c. Drawing No. 73-88-01 is the boundary survey of Guam Power Authority's bulk fuel oil storage tanks.

Drawing No. GPA 99-74 is the plot plan of GPA's bulk fuel oil storage tanks. This facility consists of 2 x 268,600 bbl fuel oil storage tanks, each 200 ft. in diameter by 48 ft. in height. The land area is ample in size for the installation of two additional future storage tanks of the same capacity.

d. Drawing No. 05-008 is the plot plan of the mooring facility for the power barge "Inductance". The power barge is owned by the U.S. Army, Corps of Engineers, made available by lease agreement to the Guam Power Authority under administrative control of the Navy/GPA power pool agreement.

The barge houses 2 - each 15,000 KW equivalent steam boilers and 1 x 30,000 KW turbine-generator.

e. Drawing No. 1102205 is the plot plan of the Tanguisson power plant. This installation consists of 2 x 26,500 KW steam turbine-generators. Unit No. 1 is owned by the Navy, unit No. 2 is owned by the Guam Power Authority. This facility is operated by GPA under the joint GPA/Navy power pool agreement.

f. Navy map showing route of the 8-inch fuel oil pipe line from the Navy's Sasa Valley pumping station to the Tanguisson Power Plant.

g. Navy map showing fuel oil pipe lines from fuel off-loading piers to fuel oil transfer pump station and storage tanks.

h. Navy plan and profile drawings, fuel pipe lines from piers to pump house. Three sets, drawings No 474046, 474047, and 474048.

i. Map showing proposed line of easement for GPA's proposed 20-inch fuel oil pipe line from Navy Fuel Wharfs "D" and "E", Apra Harbor.

j. Plot plan of GPA's main power transmission lines.

k. Drawing No. B-74-023, GPA Distribution, Island-wide Power System.

I-1. Generating station capability, date on stream, expected life and real property interest

Island-wide power generating stations are enumerated as follows with respect to (1) nominal capability (2) approximate date on stream (3)* remaining expected life and (4) real property vested interest:

Cabras Steam Power Plant

(1) 2 x 66 MW units = 132 MW

(2) Unit No. 1 on stream August 1974; No. 2 on stream June 1975.

(3) 30 years from on stream date Unit No. 1 will come to the end of its allotted service life, i.e. in the year 2004; No. 2, 2005.

(4) Cabras plant site is on land that was originally submerged; reclaimed by land fill. Title thereto granted to Guam Power Authority by an act of the Congress, USA.

Piti Steam Power Plant

(1) 2 x 22 MW units and 2 x 11.5 MW units = 67 MW

(2) 2 x 11.5 MW units went on stream in 1951; 1 x 11.5 MW unit in 1955. 2 x 22 MW units in 1964. 1 x 11.5 MW unit, because of accidental damage, is out of service. Cost of repair may preclude restoration to serviceable condition.

(3) End of allotted service life of the 2 x 11.5 MW units (30 years) in 1981; the 2 x 22 MW units in 1994.

(4) Piti Plant site is on land owned by Navy.

Tanguisson Steam Power Plant

(1) 2 x 26.5 MW units = 53 MW

(2) Unit No. 1, on stream October 1971; Unit No. 2, December 1972.

(3) 30 years from on stream date Unit No. 1 will come to the end of its allotted service life, i.e. September 2001; Unit No. 2, September 2002.

(4) The Tanguisson Power Plant site is on land acquired thru purchase from owners by Guam Power Authority.

Tamuning Diesel Power Plant

(1) 4 x 2 MW units = 8 MW

(2) These units went on stream in April 1970. Currently because of the high cost of diesel fuel oil and maintenance they are used only as a source of emergency power.

(3) 20 years* from on stream date these units will have reached the end of their service life, i.e. 1990.

(4) The Tamuning Diesel Power Plant is on land acquired thru purchase from owners by Guam Power Authority.

Dededo Diesel Power Plant

(1) 4 x 2.0 MW diesel units = 8 MW

(2) These units went on stream in October 1972. Currently because of the high cost of diesel fuel oil and maintenance they are used only as a source of emergency power.

(3) 20 years from on stream date these units will have reached the end of their service life, i.e. 1992.

(4) The Dededo Diesel Plant is on land acquired thru purchase by Guam Power Authority.

Power Barge Inductance

(1) 1 x 28 MW steam floating power plant. This plant is leased to Guam Power Authority by the Navy.

(2) It has been on stream at various locations since 1943.

(3) This facility reached the end of its allotted service life in 1973. Because of low KWH output in relation to fuel oil input it is used primarily for standby and emergencies.

(4) The barge is moored adjacent to Navy owned land. However, the mooring wharf was built and is owned by the Guam Power Authority.

*Expected life of 30 years for steam power plants and 20 years for diesel power plants conforms with regulations of State and the Federal Power Commission.

I-1-1. Esthetics of overhead power lines.

With the advent of polyvinylchloride and other plastic insulations considerable impetus was given to the installation of underground power transmission and distribution lines. The choice is primarily a matter of cost vs esthetics, opinion polls are overwhelming in condemning overhead line construction as esthetically objectionable, not in structural concept but as environmentally inharmonious.

Considerable success has been achieved through unfettered, balanced design of structures and transmission towers, including the routing of power lines to produce a low environmental profile, thereby avoiding an offensive skyline silhouette. The cost of these measures is, of course, greater than conventional design, nevertheless, it has become the accepted practice of the industry to be mindful of esthetic values, often with startling results in betterments at little additional cost. In heavily populated urban areas todays power distribution lines have no other place to go except underground.

In suburban housing areas and shopping centers it is becoming almost universal practice, primarily for esthetic reasons, to install power lines underground. The added cost of going underground, which averages approximately 2 to 3 times the cost of overhead lines, is passed on as part of the site development cost of the project.

II. Power demand projection to meet needs of the military and local economy, Guam, USA.

Capability, Guam Power Authority and Military owned power plants:

Cabras SPP*, 2 x 66 MW** units, owned by GPA	132 MW
Piti SPP, 2 x 22 MW and 2 x 11.5 MW units, owned by Navy	67 "
Tanguisson SPP, 2 x 26.5 MW units, Unit No. 1 owned by Navy; unit No. 2, GPA	53.0 "
Tamuning, 4 x 2.0 MW diesel units, owned by GPA	8 "
Dededo, 4 x 2.0 MW diesel units, owned by GPA	8 "
Inductance Power Barge, 1 x 28.0 MW Steam unit leased to GPA by Navy	28 "
System Total	296.0 MW
Maintenance outage, largest unit in system	66.0 "
Total remaining	230.0 MW
Forced outage insurance, next largest unit in system	28.0 "
Remaining to meet demand	202.0 MW
Current demand	150.0 "
Remainder to meet projected load growth	52.0 MW

*SPP: Steam Power Plant

**MW = 10^6 watts

Therefore: $150\ (1+y)^n - 150 = 52.$ $(1+y)^n = 1.347$, where

y = rate of load growth; n = time period of growth, 150 = current power demand.

For $y = 6\%$, n 5 years, $(1+y)^n = 1.338$
Thus with a 6% annual load growth new plant should go on stream within 5 years.

For $y = 5\%$, n 6 years, $(1+y)^n = 1.340$
Thus with a 5% annual load growth new plant should go on stream within 6 years.

For $y = 4.5\%$, n 7 years, $(1+y)^n = 1.361$
Thus with a 4.5% annual load growth new plant should go on stream within 7 years.

For $y = 4\%$, n 7.5 years, $(1+y)^n = 1.342$
Thus with a 4% annual load growth new plant should go on stream within 7.5 years.

For $y = 3\frac{1}{2}\%$, n $8\frac{1}{2}$ years, $(1+y)^n = 1.334$
Thus with a 3½% annual load growth new plant should go on stream within 8½ years.

For $y = 3\%$, n 10 years, $(1+y)^n = 1.344$
Thus with a 3% annual load growth new plant should go on stream within 10 years.

On or about the time new plant goes on the line, the Inductance will probably be beyond economic serviceability, and should therefore be retired for salvage. This would also apply to Piti units No 2 and 3; a total of 51 MW to be retired from the system.

Furthermore, when the new plant is added the ratio of reserve generation should remain approximately equivalent as insurance against load shedding during emergencies. Thus, it is reasonable that with new plant added, outage reserve generation consist of the largest unit plus two of the next smaller units, i.e. 66 + 2(26.5) = 119 MW.

New Plant capability.

150 $(1+y)^n$ + retired plant + reserve generation - existing plant = new plant capability, where y = % annual load growth; n = time period of load growth, years.

Expressed in numbers, new plant capability =
150 $(1+y)^n$ + 51 + 119 - 296 = 150 $(1+y)^n$ - 126

For y = 6%, n 5 + 5*, 150 x 1.06^{10} - 126 = 143 MW

For y = 5%, n 6 + 5*, 150 x 1.05^{11} - 126 = 131 MW

For y = 4.5%, n 7 + 5*, 150 x 1.045^{12} - 126 = 128 MW

For y = 4%, n 7.5 + 5*, 150 x $1.04^{12.5}$ - 126 = 119 MW

For y = 3½%, n 8½ + 5*, 150 x $1.035^{13.5}$ - 126 = 113 MW

For y = 3%, n 10 + 5*, 150 x 1.03^{15} - 126 = 108 MW

*Years beyond on stream date of new plant until another unit must be added.

Optimizing for best results in minimizing cash flow and dollars per KW in plant investment:

a. Anticipated load growth say 5%. Do not wait out the 6-year time limit for new plant, start with the purpose in mind of new plant on stream in 4-years and include only 4-years until a second unit will be scheduled to go on stream, thus:
150 x 1.05^8 - 126 = 96 MW. Add 1 x 87 MW unit with 10% 4-hour minimum overload capability, total 95.7 MW.

b. Anticipated load growth say 4%. Reduce 7.5-year time limit to 5-years plus 5-years for second addition thus:
150 x 1.04^{10} - 126 = 96 MW. As in a. above add 1 x 87 MW unit with 10% 4-hour minimum overload capability, total 95.7 MW.

Continuing on the theory that power demand will increase by 5% annually; Cabras No. 4 must be on stream in 1985. Computed as indicated under "new plant capability" above:

$150\ (1.05)^{13} + 51 + 149^* - 392 = 91$ MW

*Reserve power computed as the new unit plus 2-units at Tanguisson. Because of the small difference, install a second 96-MW unit to match No. 3 at the Cabras plant. With the additions as indicated Cabras will now consist of 2 x 66 MW units plus 2 x 96 MW units; a total installed capability of 324 MW. This will take care of projected power demand at 5% per annum to 1990.

Projections at the same rate of power demand beyond 1990 are computed as follows:

$150\ (1.05)^{18} + 95^* + 149 - 488 = 117$ MW

*Piti units No. 4 and 5 retired for salvage.

Install one new 120 MW unit on the old Piti site. This unit to be on stream early in FY-1990. It will take care of load projection to 1995.

The capacity of the new unit to be installed in 1995 is computed as follows:

$150\ (1.05)^{23} + 95 + 173^* - 608 = 121$ MW

*Reserve power equal to the new unit plus 2 units at Tanguisson. Install one new 120 MW to match the first 120 MW unit. Both units to be installed on the old Piti site. This will take care of load projection at 5% to the year 2000.

III. Projected Power Generation and Fuel Oil Consumptinn, Island-wide Power System

a. The pattern of island-wide power generation became erratic after typhoon Pamela, affecting FY-76, 77 and 78, thereafter the rate of growth is expected to revert to a stable condition. Thus at 5% annual increase in power generation, the progression representing growth is in the form of $y(1+x)^n$, where y = preceding FY generation, x = rate of annual increase, n = number of years projected. Fuel oil heating value assumed at 147,000 Btu/gal, the approximate current value.

For FY-76, gross generation = 994×10^6 KWH.
For FY-77, gross generation is estimated at $1{,}018.4 \times 10^6$ KWH.
For FY-78, gross generation is estimated at $1{,}117.4 \times 10^6$ KWH.
Following FY-78, power production, estimated at 5% per annum, results in the following progressive growth in generation:
$1{,}117.4\ (1 + 0.05)^1 = 1173.3 \times 10^6$ KWH. 5-years beyond FY-78 in FY-83, generation will have reached approximately:
$1{,}117.4\ (1 + 0.05)^5 = 1426.1 \times 10^6$ KWHs.

b. Fuel oil consumption is projected as follows. First, however, recognition must be given to the variables involved in power generation. All plants are not equally efficient, there is also a difference in efficiency resulting from the load carried by each plant from minimum to full load. Thus the result will depend on the makeup of the mix and load carried by each plant. At the lower end of the spectrum is the power barge Impedance and the older units in the Piti plant which will produce from 10 to 11 KWH per gallon of fuel oil. At the upper end is the new Cabras steam power plant which will produce from 15 to 16 KWHs per gallon of fuel oil. Assuming normal plant maintenance routine without forced outages fuel oil consumption, based on 5% per annum increase in power generation beyond 1978, is expected to range as follows, where (Gross KWH generation) divided by (KWH/Gallon of fuel oil attainable under most favorable conditions times the proportionalty factor of the plant mix as related to the combined operational efficiencies times 42, the number of gallons in a bbl of fuel oil) = bbls of fuel oil consumed.

1) For FY-76, as indicated in a. above, gross generation = 994×10^6 KWH. Fuel consumed = 1,802,000 bbls No. 6 resid; 5,050 bbls diesel grade No. 2.

2) For FY-77, as indicated in a. above, projected gross generation = $1{,}018 \times 10^6$ KWH. Fuel consumed = 1,826,811 bbls No. 6 resid; 5,200 bbls diesel grade No. 2.

3) For FY-78, as indicated in a. above, projected gross generation = $1{,}117.4 \times 10^6$ KWH. Fuel consumed = 1,886,842 bbls No. 6 resid; 5,200 bbls diesel grade No. 2.

4) For FY-79: $(1{,}173.2 \text{x} 10^6) / (15 \text{x} 0.94 \text{x} 42)$ = 1,981,087 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

5) For FY-80: $(1,231.8\times10^6)$ / $(15\times0.93\times42)$ = 2,102,407 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

6) For FY-81: $(1,293.4 \times 10^6)$ / $(15\times0.92\times42)$ = 2,231,539 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

7) For FY-82: $(1,358.1\times10^6)$ x $(15\times0.92\times42)$ = 2,343,168 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

8) For FY-83: $(1,426.0\times10^6)$ / $(15\times0.91\times42)$ = 2,487,354 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

9) For FY-84: $(1,497.4 \times10^6)$ / $(15\times0.91\times42)$ = 2,611,896 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

10) For FY-85: $(1,572.3\times10^6)$ / $(15\times0.90\times42)$ = 2,773,016 bbls of No. 6 resid; diesel fuel oil estimated at 5,200 bbls.

In the above chronology, Cabras reaches maximum utilization in FY-78. Thereafter, use of less efficient plant must be increased, resulting in a decline of the mix from 0.94 in FY-79 to 0.90 in FY-85.

The effect of operation of old inefficient plant is illustrated as follows:

In FY-80 plant mix economy will decline from 0.94 to 0.93, resulting in an increase in fuel oil consumption of 2,102,407 $(1 - \frac{0.93}{0.94})$ = 22,366 bbls of fuel oil because of decline in plant mix operation of 1-point from 0.94 in FY-1979 to 0.93 in FY-1980.

For FY-85 the excess fuel used comes to 2,773,016 $(1 - \frac{0.90}{0.94})$ = 118,000 bbls of fuel oil because of projected decline in plant mix operation of 4-points from 0.94 in FY-1979 to 0.90 in FY-1985.

The foregoing equates to 22,366 $(1.39464)^n$ in excess fuel, where n = years beyond FY-80, thus:

FY-80	22,366 bbls
FY-81: 22,366 (1.39464)	31,193 "
FY-82: 22,366 $(1.39464)^2$	43,502 "
FY-83: 22,366 $(1.39464)^3$	60,670 "
FY-84: 22,366 $(1.39464)^4$	84,613 "
FY-85: 22,366 $(1.39464)^5$	118,000 "
Total FY-80 thru FY-85	360,344 bbls

Fuel oil pass thru rate per KWH

GPA rates for energy for any monthly billing period shall be increased or decreased by \$0.016 per KWH for each increase of \$0.010 per million BTU in the cost of fuel for electric power generation, above \$0.44 per million BTU. Thus:

BTU/bbl x \$0.044 x 10^{-6} = cost per bbl as base without escalation.

Increase beyond \$0.44 per million BTU =

$\left(\frac{\text{Cost/bbl}}{\text{Btu/bbl}} - \$0.44\right) \times \$0.016$ = fuel oil pass thru to consumer per KWH consumed.

Example, assume fuel oil cost at \$10.00 per bbl; heat value 147,000 Btu/gal or 6,174,000 Btu/42 gal bbl:

$\frac{\$10.00}{6,174,000} = \$1.61969\text{/m Btu}$

$1.61969 - $0.44 = $1.17969

$1.17969 x $0.016 = $0.018875, the fuel oil pass thru per KWH consumed.

Economics of Power Generation vs Fuel Oil Cost Pass Thru

a. At 14 KWH/gal of fuel containing 147,000 BTU in heat units plant operating efficiency =

$\frac{14 \times 3413}{147,000}$ = 32.50%, where 3413 = BTU_n/KWH.

14 x 42 = 588 KWH/bbl

147,000 x 42 = 6,174,000 BTU/bbl

6,174,000 x \$0.44 x 10^{-6} = \$2.71656/bbl, the base price, no escalation.

$\frac{\$10.00 - \$2.71656}{588}$ = \$0.0123868/KWH

Pass thru = $0.018875/KWH

$0.018875 - $0.0123868 = $0.006568 per KWH for station, line losses and uncollectable accounts, representing 35% of the pass thru rate.

b. At 13 KWH/gal of fuel containing 147,000 BTU in heat units, plant operating efficiency =

$\frac{13 \times 3413}{147,000}$ = 30.18% ; 13 x 42 = 546 KWH/bbl

$\frac{\$10.00 - \$2.71656}{546}$ = \$0.01334/KWH

$0.01887 - $0.01334 = $0.00553/KWH for station, line losses and uncollectable accounts, representing 29% of the pass thru rate.

c. At 12 KWH/gal of fuel containing 147,000 BTU in heat units, plant operating efficiency =

$$\frac{12 \times 3413}{147,000} = 27.86\%$$

$$12 \times 42 = 504 \text{ KWH/bbl}$$

$$\frac{\$10.00 - \$2.71656}{504} = \$0.01445/\text{KWH}$$

\$0.01887 - \$0.01445 = \$0.00442 per KWH for station, line losses and uncollectable accounts, representing 23% of the pass thru rate.

IV. Fuel Oil Bulk Storage Tanks

The existing fuel oil storage tanks serve as bulk storage to fuel the island-wide steam power plants, including both Navy and Guam Power Authority's installations. Tanks are located in the near vicinity of the Navy owned Piti power plant. The storage tanks including the fuel oil transfer pumping station are owned by Guam Power Authority. The pumping station transfers fuel from the main storage tanks to the island-wide steam power plants, including the pumping of fuel through the overland pipe line to the Tanguission power plant. Each of the two storage tanks has a capacity of 268,600 bbls. They are standard API cone roof type tanks, each installed within a separately diked containment area.

The storage capacity of the two tanks mentioned above will be adequate for fuel storage needs up to the time unit No. 4 is programmed for installation at the Cabras site, when consideration must be given to the installation of storage tanks No. 3 and 4 of the same capacity as existing tanks No. 1 and 2. There is ample land area within the existing site for the installation of future tanks No. 3 and 4. However, on or before the approach of the year 2000 additional land should be acquired for future fuel oil storage requirements.

The existing tanks as well as future additions can be fueled from (1) Guam Oil and Refinery Company's Agat refinery (2) direct from the Guam Oil and Refining Company's Apra Harbor fuel wharf or (3) from Navy's Apra Harbor fuel wharfs "D" and "E". However, in the latter instance a fuel pipe line must be installed from the interconnection of wharfs "D" and "E" to the bulk storage tanks.

IV-1. Life expectancy of fuel oil storage tanks and pipe lines. Storage tanks as well as pipe lines are usually accorded a life expectancy of 40 years. This assumes that the storage tanks will be protected with anti-corrosion paint and underground pipe lines taped to resist corrosion and cathodically protected. All fuel oil pipe lines serving the Island power plants were installed within the past 3 years, except the 8-inch overland (17.5 mile) Tanguisson pipe line installed in 1969.

V. Load Growth Projection

a. Civil Economony

The following items are believed to be of significance in projecting the load growth pattern. Percentages assigned will vary with time, but the sum total may not be too far from realization.

Population growth, including housing, public schools, utilities, etc.	1%
Improved standards of living	½%
Tourist industry	2%
Commercial enterprises	½%
Light industry	½%
Agriculture	½%
Total	5%

In the light of current efforts to achieve economy in the use of electricity, the above estimate may be a bit optimistic initially, since demand will, for a while, be offset by frugality in use of electricity.

b. Military Installations

The present military construction program calls primarily for rehabilitation of existing installations as the aftermath of typhoon Pamela. However, included in the program are the following items:

1) Under construction by Navy:

Post Office	Bowling alleys (2)
Armory	Medical/dental facility
Gymnasium	Cold storage warehouse

2) Under design by Navy:

   Secondary sewage plant

   Night recreational facilities

3) Under construction by Air Force (AAFB)

   Commissary refrigerated warehouse

   Commissary expansion

   500 housing units

It is estimated that the above construction programs will result in an increase in power demand of approximately 5%. However, this may be offset somewhat initially as the result of the economy program in the use of electricity.

Since civilian and military power demands are computed as concurrent, the resultant overall system projected power demand is 5%. Presently the military contributes approximately 45% to the total power demand; civilian 55%.

The subject matter under this section has been developed from sources considered reliable. However, because of the unpredictable nature of the variables, confirmation should be obtained from the affected agency with respect to any specific developments.

V-1. Load shedding schedules.

Load shedding when necessary, because of forced outages, is accomplished by means of outage rotation within roughly three of Guam's central metropolitan areas in equal on/off hourly periods. There are no power interruptable facilities on Guam for either short or long outage periods, either military, industrial, commercial or public utility. Although the military has some emergency generation, these are for emergencies only to protect essential services.

Companies in the US get a break thru interconnection to protect each other and to reduce the cost of power plant needed only during maintenance and forced outages. This is, of course, not possible on Guam. It should be noted that scheduled maintenance outages are not of short duration, e.g. each of the boilers in the steam power plants must be shut down annually for not less than 3 weeks to accomplish essential maintenance.

Major power outages in FY-74 thru FY-76 were caused by (1) Typhoon Pamela which caused widespread damage to primary and secondary power transmission and distribution facilities (2) two direct strikes by lightning which damaged substation apparatus and (3) outages on two occasions, with damage to substations, caused by snakes crawling up into and short circuiting overhead bus installations. Remedial measures have been taken to prevent re-occurrence of short circuits by snakes in station overhead bus work.

V-1-1. Industrial Expansion and Development.

The GORCO refinery will probably expand only moderately in future years unless a foreign market can be found for gasoline, a product currently not being produced by the Guam refinery. Gasoline is marketed on Guam by Exxon and Mobil; demand is not sufficient to warrant local production. Assuming Saipan and other Mariana Islands were included, this still would not suffice in quantity for economical production by the Guam refinery. If foreign marketing for long term sales could be developed, the Guam Oil & Refining Company has ample real estate for expansion of refining facilities to 200,000 bbls of products per day.

Air Travel Potential

Guam is acknowledged to be strategically located with respect to air travel in the South Pacific. Thus Guam is in a fortunate position to benefit through service oriented logistics for air travel. The research needed for projection of future facilities to support traffic growth, including possible need for relocation of the airport to permit expansion in a less congested area is beyond the scope of this report.

Mariculture as an Industry

Through support and coordination of the University of Guam Marine Laboratory, maricultural pursuits, where most favorable within the area of the Mariana Islands, could possibly be profitably developed as a viable food product industry. It is suggested that this could apply to cultivation of salt water plants as well as the growing of salt water fish and shellfish.

Horticulture products to support industry

Probably one of the many tropical products enjoying a profitable worldwide market is palm oil extracted from a species of palm tree bearing huge clusters of small nuts from which edible oil is extracted for use in homogenized filled milk, oleomargarine and a host of other food products. This species of palm is native to Africa, not the kind of coconut palm tree common to Guam and the Mariana Islands. There are of course many tropical plants grown to supply ingredients for food products, pharmaceutical preparations and other needs of industry. Research might uncover some exceptional possibilities.

VI. Guam Oil and Refining Company Production Estimate***

Fiscal Year	Throughput	Fuel Oil Yield	BBL/Day	Clean Products*
1977	30,000	25%	7,500	22,500
1978	35,000	45%	15,750	19,250
1979	40,000	45%	18,000	22,000
1982**	50,000	45%	22,500	27,500

*Clean Product Approximation

Fuel oil, light	43%	JP-4	26%
DFM	19%	JP-5	10%
Asphalt	1.9%	LPG	0.1%
			100.0%

**Since future market conditions are unpredictable, estimates beyond 1982 would have no meaningful connotation.

***Because of the unpredictable nature of the variables, confirmation should be obtained from Guam Oil and Refining Company respecting any specific development.

VII. Solar Sea Power

Guam is probably one of the world's most favorable sites for the development of solar sea power. The following paper is submitted herewith to illustrate feasibility of solar sea power as an alternate source of energy:

a. Letter prepared by the writer, dated 19 August 1974 with inclosure depicting temperature profiles, addressed to the Honorable Antonio B. Won Pat, Congress of the United States. (See Page 28A and 28B)

The bathymetric chart, Geology and Hydrology of Guam, Mariana Islands, US Geological Survey 403B:31-B76 indicates very favorable submarine profiles for location of land based solar sea power generators in the vicinity of the Cabras Steam Power Plant site, southwesterly off Cocos Island or just off Facpi point, south of Nimitz Beach. In the case of a site near the Cabras Power Plant the old Navy quarry site might conceivably be set aside pending decision of feasibility studies.

GUAM POWER AUTHORITY
P. O. BOX 2977
AGANA, GUAM 96910

August 19, 1974

The Honorable Antonio B. Won Pat
216 Cannon House Office Bldg.
Congress of the United States
House of Representatives
Washington, D.C. 20515

Dear Congressman Won Pat:

The purpose of this letter is to enlist government interest in seriously considering the Island of Guam as potentially advantageous for development of solar sea power. Because of its pollution free and self-renewing characteristics solar sea power has taken on added importance as a source of energy totally independent of fossil or atomic fuel.

Thus for the purpose of showing the potential possibilities of development of solar sea power on Guam, we are enclosing thermal profiles of sea water temperatures from surface to a depth of 3000 feet. Although the temperatures were measured at 2.5 and 3.5 miles from the shore, it is felt that it would be practicable to come close enough to land for construction of a shore based station without sacrificing too much in terms of reducing the temperature differential. For example, the charts show that at a depth of 1500 to 2000 ft temperature changes diminish rapidly with the result that within this range depth would probably bottom out at an optimized break even point. Thus at 82° F surface water and 45° F at a depth of 1500/2000 ft the differential would be 37° F. We believe that this compares favorably with conditions prevailing in other tropical zones. Another favorable factor is that the waters surrounding Guam remain markedly constant in the 82/85° F range throughout the year.

The Japanese are presently contemplating the installation of two (2) 10 MW land based solar sea power generating units on the Island of Nauru in the South Pacific for the Nauruan government as a continuous source of 10 MW (1-unit standby), sufficient for all Island Power needs. Also of special interest is the fact that cold water from the depths of the sea is extremely rich in nutrients and that shell fish will grow very fast in feeding on the micro-organisms contained therein. Thus after serving the purpose as the condensing medium (heat sink) for power generation, the warmed water could serve to support a maricultural industry. Given time for development, this could result in a major food production enterprise for the Island of Guam.

It is our premise that the potential possibilities here on Guam for the development of solar sea power may be better or approximately equal to other potential sites in tropical areas where such developments hold promise of practicability. We, therefore, respectfully request the cooperation of your good office in placing this petition for the consideration of Guam as a potential site for solar energy development in the hands of those who have been designated as agencies of the government to research, promote and implement this source of inexhaustable energy.

In view of the encouraging potential possibilities for development of solar power on Guam, your early attention to the foregoing will be greatly appreciated.

Respectfully,

E. W. SCHAARDT
Chairman, Board of Directors

EWS/WFP/tmd

Enclosure

VII-1. Tide current generators.

It is believed that studies of tidal flow in narrow channels between islands or submerged reefs may reveal areas where tide flow generators would be feasible and practicable for the generation of power. Tide flow would, of course, be variable in direction and magnitude, nevertheless, it is believed that where currents are pronounced a considerable amount of power could be generated during each tidal cycle. Research and exploratory work might well be worth the effort.

IX. Additional Comments and Discussion

The following amplification notes refer to letter of 3 May 1977 from the Coordinator, Coastal Zone Management Section, Bureau of Planning, Government of Guam.

Land holdings, leases, rights-of-way

The planned expansion of main and primary power transmission lines is shown on GPA Drawing No. B-74-023. The dates given are subject to change depending on the magnitude and direction taken by load growth. It is suggested that it would be good policy for the government to take options or lease rights-of-way at the earliest practicable date for all lines planned to be in operation 5 years hence. There is no alternative to early acquisition of rights-of-way, it will pay dividends in avoiding delays and cost of lease holds. Aerial surveys will prove invaluable in site feasibility studies and plotting of alternate routes.

Regulations and Permits

1) Corps of Engineers Permits

Except for a permit stipulation on building a small boat launching ramp and trailer car parking area, GPA has no outstanding U. S. Army Corps of Engineers permit obligations respecting the siting of the Cabras Steam Power Plant.

In the case of the Tanguisson Power Plant site, the U. S. Army Corps of Engineers permit was a matter resolved between the Corps and the Navy, since construction of this facility was initiated and completed by the Navy.

2) The Clean Air Act

GPA's Federal EPA compliance schedule for sulfur dioxide was amended by Court decision dated 23 August 1976, this decision extended GPA's compliance date calling for either stack gas scrubbers in operation by 31 July 1981 or low sulfur fuel oil by Agusut 1979. This is in reference to the Cabras Steam Power Plant, which comes under Federal New Sources Performance Standards.

3) Water Pollution Control Act

GPA applied for and was qualified under the "less stringent" regulations of the Federal Water Pollution Control Act. Under "less stringent" GPA must submit plans for review by EPA, 9th Region showing measures proposed for no increase in temperature of the waters discharged from the Cabras or Tanguisson Power Plants above the normal temperature of the receiving waters. It is a further requirement, unless the law is amended, that zero temperature difference be accomplished by 1981.

Load Shedding (reference Section V-1)

Since GPA has no consumers taking large blocks of power that could be committed to an interruptable load schedule, resort must be had to power outage rotation by areas within districts served from the principal load distribution centers. Currently reserve for maintenance and forced outages has, it is understood, been established as the sum of the largest and next largest turbine-generator in the system, i.e. one 66 MW Cabras unit plus the power barge Inductance; 66 + 28 MW respectively or a total of 94 MW.

Major power outages (reference Section V-1)
Major power outages are usually caused by line faults of sufficient magnitude to trip out main generators and problems related to getting main generators restored to the line. For the past several years line faults per se have caused outages of relatively short durations, minutes to a matter of about 4 hours.

Rate structure anf fuel oil price pass-through (ref. Page 15, Sec. III)
Rate structure and application of fuel oil price pass-through is described under "Fuel oil pass thru rate per KWH" on page 15 of this report.

Electric power needs beyond the year 2000 (ref. Page 11, Section II)
Beyond the year 2000, in 2005 plans must be ready for the installation of the first unit in the 150 MW size, assuming a continuing load increase of 5% annually. Since the Tanguisson and Cabras units will have reached retirement age a second 150 MW unit must follow shortly after the first 150 MW unit is installed. This will carry power needs beyond the year 2010.

Life expectancy of present fuel oil pipe lines (ref. Section IV-1)
This item is covered in Section IV-1 of this report. Note that all pipe lines installed underground are cathodically protected and should therefore last for 40 years, the expected life span or longer.

Market logistics for GORCO products (ref. Section V-1-1)
Logistics, land use and other developments are discussed under Section V-1-1 of this report.

Solar Sea Power (ref. Section VII)
As mentioned in Section VII of this report the old Navy quarry site on Cabras Island could probably serve as a land based solar sea power plant site. In the case of Cocos Island or Facpi Point, site development would involve reclamation of reef area by dredge operation. Feasibility studies should be made to pinpoint the most favorable site with respect to environmental impact and economic factors.

Transmission Line Size
The existing 115 KV transmission line and planned expansion will be ample in voltage for Guam's power needs to the year 2000. Right-of-way width depends on conductor configuration, which will probably continue as at the present time with two-circuit vertical configuration. In this case the line right-of-way will be approximately 100 feet in width and greater depending on length of span and height of tower.

Transmission line towers, conductors and insulators are generally given a service life of 60 years, although the actual expected service life could exceed this figure by many years. GPA will need to take action at an early date to acquire right-of-way for extension of the existing power transmission system.
The same right-of-way can be used jointly for overhead power transmission and underground fuel oil pipe lines. This would also apply to underground fuel oil pipe lines and underground power lines assuming that there is adequate separation between fuel lines and power cables. Isolation is usually achieved by installing underground power cables on one side of a highway; fuel lines on the opposite side.
Other items in reference to transmission line rights-of-way are covered under the previous paragraph titled "Land holdings, leases, rights-of-way".

Visual impact of future transmission lines (ref. Section I-1-1)
Discrete routing of power transmission lines can often avoid objectionable skyline and other exposed effects. Life cycles of the new plastic forms of underground cable insulation have not been historically determined except through life acceleration tests, thus a limit of 20 years is currently assumed, although this may not be realistic; only time will tell. Also, note Section I-1-1 on the esthetics of overhead power transmission lines, and comparative costs of underground lines.

Improvements in environmental and esthetic impacts
(reference Section I-1-1)

It is believed that discrete routing of high-tension transmission lines including, where appropriate, use of line supporting structures of stream lined, unencumbered design will result in public acceptance without severe criticism or obvious ruthless scarring of the environment.

Real Property Resources (ref. Page 11, Section II)

With reference to real property resources, GPA is fortunate in that the Cabras Plant, within its present boundaries, can be expanded by the addition of 2 additional steam turbine-generators. After the Cabras area is fully occupied GPA can move into the Piti Power Plant area, owned by Navy, for installation of additional generating plant capable of supplying power to the year 2000. Reference thereto is contained in Section II, page 11 of this report. It is, also, to be noted that GPA owns real property for fuel oil bulk storage tanks to take care of needs to the year 2000.

Major changes in fuel oil pipe line systems (ref. Page 18, Section IV)

No major changes or additions will be required in fuel oil delivery or transfer pipe line systems to take care of power plant fueling needs to the year 2000.

GORCO's real property assets vs production (ref. Section V-1-1)

In reference to GORCO refinery's real property assets in relation to production capability reference is made to Section V-1-1 of this report.

Routes proposed for future extension of power transmission lines

Extensions of transmission lines are marked on GPA drawing No. B-74-023, included are dates when the indicated extensions will probably take place.

Load growth projection weights (ref. Page 21, Section V)

The weights given to load growth projection may be off the mark in the assignment of unit values in some instances, however, it is felt that in the plus or minus aggregate the sum may balance. Obviously 2% growth is too high a mark if nothing is going to be done to encourage tourism, it will continue to slide downhill with a negative mark for load growth. Tourism as an industry is very competitive, but in spite of this if made attractive it is self-perpetuating. At the present, the reverse is true on Guam, e.g. a safe well lighted broad-walk along Tumon bay beach is long overdue, neither is beach frontage being improved, bicycle trails or non-existent, etc. Tourists continue to be victimized by thieves and thugs in or out of tourist hotels. Work done for tourists in improving beach fronts, etc. would also benefit local residents. If overdue improvements are not gotten underway soon, more hotels may close down.

Life expectancy of power generating units (ref. Section I-1)

Values of life expectancy are given under Section I-1 of this report.

AQUACULTURE AND ITS POTENTIAL ENVIRONMENTAL IMPACT ON GUAM'S COASTAL WATERS

by

William J. FitzGerald, Jr.

August, 1977

This study was funded by a grant from the
Office of Coastal Zone Management, U.S.
Department of Commerce

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INTRODUCTION

Aquaculture has the potential of suppling a substantial portion of Guam's consumption of fishery products, which is almost exclusively imported to the island at present. Some of the worlds countries obtain 20 to 40 percent of their aquatic food products through aquaculture, including Indonesia, India, and China; while in the United States an estimated 2 percent of fishery products consumed (mainly oysters, catfish, and trout) are produced by aquaculture (Corbin, 1976). In addition to the on-island market, aquaculture is an industry that can produce an export product. Together, these features give aquaculture an important potential role in Guam's economy.

A properly managed, vertically integrated aquaculture system covers the whole spectrum of the production of aquatic species from energy input to the marketing of the product (i.e., hatchery operation, grow-out phase, manufacture of feeds, processing, and marketing of the product). The expansion of aquaculture into a large capital generating enterprise encompasses a number of managerial problems that must be overcome to be successful. The major areas of concern are species for culture, biological technology, engineering technology, site location, feed, manpower, marketing, as well as legal, institutional, and financial considerations. Such systems are being developed in the United States, especially in the culture of the channel catfish.

The development of aquaculture facilities, both marine and freshwater, requires a well thought out islandwide plan, that will take into consideration its positive as well as negative aspects in regards to the economy and environment. Guidelines must be placed on the development not to hinder, but to restrict abusive use of the island's natural resources. These guidelines will have to be part of a comprehensive plan and enforced by the involved governmental agencies.

LAND RESOURCES

Aquaculture development should be limited to the central and southern area of Guam, since the use of water from the lens system which is the main source of potable water for Guam would possibly put an excess demand on this finite water supply. In addition, the major part of the northern area consists of limestone which would be unsuitable for pondages due to its permeability. Plastic-lined or concrete tanks would be required. Full explotation of southern sites should be the priority.

Criteria for land to be used for aquaculture ponds are as follows: The soil should be of character to retain water, preferably having a minimum of 25% clay. Fertile soil is prefered, but marginal soil can be used through the addition of fertilizers and lime. The area should be free of flooding or corrective means can be made without excessive investment. The soil should be free of pollution that might endanger cultured species. Prior knowledge of the land use would be informative to the type of pesticides or chemicals used. The contour distance should be greater than or equal to 100 ft. (30.9 m) for every 10 ft. (3.1 m) horizontal rise (slope maximum 10%). The size of the ponds becomes smaller as the contour interval approaches 100 ft.; beyond this, pond construction of small ponds becomes too costly. The land to be useable must be accessible by vehicle year round. This is a requirement for proper management. The area must have suitable topography so as to allow the complete drainage of ponds.

An estimated total land area suitable and available (no permanent structures) for aquaculture on Guam is 3652 ha. This estimation is based on the soil type and terrain. Figure 1 shows the delineated areas and Table 1 shows the quantity of area within each site. The preferable soils are Pago and Inarajan clays. Of the two clays under the soil type number 6, the Agat clay is not suitable for ponds, mainly due to its excessive slope. The Atate clay (#6) is marginally acceptable. It depends on the depth at which the C horizon is located. There are ponds constructed on this soil type. The total estimated suitable land area does not indicate the potential developable land,since each site must be considered seperately with referral to the type and quantity of water supply available. This will then determine how much of a given site can be developed. Naturally, conflicts with other uses of the land (e.g., agriculture, housing development) will further limit the development.

All aquaculture practices within the marine environment are considered to be in navigable waters and thus require a permit from the Army Corps of Engineers. Aquaculture sites for the culture of marine organisms are limited to areas that afford a reasonable degree of protection from surf, and storm damage. The major sites that afford such protection are Apra Harbor between the drydocks and Polaris Point (Sasa Bay) and Cocos Lagoon primarly in the area around Achang Bay (possible siganid culture in sea grass beds). The Inner Habor of Apra Harbor and the salt water pond adjacent to San Luis Point have suitable sites, but are restricted due to Naval operations. In addition, the Piti Channel area has suitable physical features; however, the possibility of toxic effluents from the nearby power plants have to be concidered. Small protected bays along the southeast coast of Guam (e.g., Pauliluc Bay, Agfayan Bay) can be utilized for small scale culture operations. The use of large areas of reef flats around Guam would be ill-advised due to the environmental impact such operations would have and the very limited degree of managebility of such sites without major construction and alteration of the reef flat areas. However, the impoundments on the reef flat created by the construction of the sewage disposal plant in Agana could be technically utilized for aquaculture.

Table 1. Land Area Suitable for Aquaculture.

Map Section	Soil Types											
	#2 Toto Clay Hectares		#3 Chacha-Saipan Clay Hectares		#6 Atate-Agat Clay Hectares		#9 Pago Clay Hectares		#10 Inarajan Clay Hectares		#11 Mucks Hectares	
	Total	Available	Total	Available	Total	Available	Total	Available	Total	Available	Total	Available
East Guam												
1.	8	8	793	238								
West Guam												
1.	45	45	16	0	162	130	40	16	25	12	163	147
2.			7	0	11	10	12	0	90	45	25	22
3.			79	35	4	4	60	0	10	10	32	0
4.			2	0	3	2	129	97	16	14	4	0
5.			20	0	20	10	89	45	125	100	4	4
6.			30	0	119	30	26	13	13	13	29	7
7.			10	0	34	0	56	56	54	0	8	2
8.			36	0	63	0	21	21	15	0		
9.			11	0	145	36	29	29	2	2		
10.					4	4	90	90	7	7		
11.					4	4			78	39		
12.					152	152			21	21		
13.					26	26			40	40		
14.					3	3						
15.					136	68						
16.					172	172						
17.					2	2						
18.					27	27						
19.					19	19						

South Guam												
1.					86	69	4	4	32	0	3	3
2.					25	25	3	3	4	4		
3.					20	20	26	13	15	15		
4.					32	16	3	3	3	3		
5.					6	6	24	0	145	102		
6.					7	7	17	17	9	9		
7.					35	35	6	6	2	2		
8.					43	43	24	24	23	23		
9.					15	15	52	52	64	51		
10.					5	5	285	285	4	4		
11.					579	579	5	5	2	2		
12.					36	36	3	3	59	59		
13.					161	129	10	10	8	8		
14.					39	39	5	5				
15.					31	31						
16.					5	5						
Total	53	53	1,004	273	2,231	1,759	1,019	797	866	585	268	185

WATER RESOURCES

Aquaculture is dependent on an adequate quantity and quality of water. The latter can be influenced by the use of pesticides or other chemical agents, sewage and other pollutants from the adjacent land. In the case of marine aquaculture it is also susceptable to oil spills. Possible deleterious effects of toxins or pollutants on cultured organisms are mortality, injury, interference with growth or other vital functions, concentration in the organisms to such an extent as to render them unfit for human consumption or making them unpalatable. Organisms under intensive aquaculture practices are often under physiological stress due to artificial diets being incomplete in nutritional needs, and unnatural crowded living conditions that possibly cause hormonal or other biochemical imbalance. Therefore, they are rather susceptable and vulnerable to further deterioration of water quality, often more so than organisms in the wild.

The average daily quantity of water that needs to be added to a pond to maintain the water level is 1.3% of the total volume. This is the water lost due to evaporation and seepage. Some water is gained through rainfall, but there is an average net lost of 34,000 gal/day/ha of pondage. Thus, this requires a minimum continuous water flow of 23.6 gal/min/ha. This figure is based on the actual operation of the Division of Aquatic and Wildlife Resources; ponds at Talofofo during 1974 to 1975. During this period, precipitation averaged 0.275 in/day and evaporation averaged 0.200 in/day. During periods of drought a larger volume flow will be required. Likewise, during periods of excessive rainfall, less volume will be required.

A large-scale development of pondage would necessitate the construction of a dam to assure an adequate flow of water during the dry season and to allow the full potential of the area to be developed. For the construction of a dam, a permit from the Army Corps of Engineers is required for rivers having an average annual flow of 5 cu. ft/sec or greater. A permit is also required from the Guam Environmental Protection Agency for the construction of any obstruction of a waterway. The construction of government-funded dams (e.g., proposed Ugum River Dam) should be encouraged so as to allow the fuller utilization of the island's water resources. Aquaculture would be greatly benefited by such conservation measures of the island's water supply. If no dam is to be constructed at the pondage site the maximum area that can be developed should be based on the minimum flow months of the year (Table 2&3). Following this procedure would greatly reduce the area that could be supported by the water supply. Drainage and filling of ponds should be coordinated to best utilize the water supply. Tables 2 & 3 gives the maximum area that can be developed using the average flow over a number of years for a given river system that has been monitored by the U.S. Geological Survey personnel. The criteria for this area of development is the damming of the river with the option of 25, 50, or 75% of the average flow being utilized for pondages. In areas with the river systems flow rate not being monitored, an estimated average discharge for one square mile of drainage area on Guam is 2 million gallons per day (personal communication, Chuck Huxel).

The use of wells and springs can serve as a main or supplemental water supply in the southern areas. Thorough aeration is generally required of well water before use in the ponds. This type of water supply has the

Table 2 . Minimum Flow Recorded Permanent Monitor Stations. 1) 34,000 gal/day/ha. 2) 1.3% Evaporation seepage water/day. 3) 1 cu ft/sec = .646317 x 10^6 gal/day.

Station	Finile River	Umatac River	Geus River	Inarajan River	Tinaga River (Pauliluc River)
Number of Years Monitored	15	23	22	23	23
Cu ft/sec/month	3.25	6.30	0	32.89	7.43
Gal/day	70,018	135,727	0	708,579	160,071
Pond Area Supported Hectares (100% Utilization)	2.1	4.0	0	20.8	4.7
		Long Term Average Flows			
Cu ft/sec/month	42.0	251.7	90.6	513.0	166.8
Gal/day	904,845	5,422,600	1,951,877	11,052,020	3,593,523
Pond Area Supported Hectares (25% Utilization)	6.7	39.9	14.4	81.3	26.4
Pond Area Supported Hectares (50% Utilization	13.3	79.7	28.7	162.5	52.8
Pond Area Supported Hectares (75% Utilization)	19.9	119.6	43.1	243.8	79.3

Imong River	Almogosa Spring	Almogosa River	Maulap River	Ylig River	Pago River	Total
14	19	4	4	23	24	
18.39	0.28	10.07	12.43	4.72	2.53	
396,192	6,032	216,947	267,791	101,687	54,506	
11.7	0.2	6.4	7.9	3.0	1.6	62.4
Long Term Average Flows						
297.6	108.0	169.8	129.3	846.0	720.0	
6,411,465	2,326,741	3,658,154	2,785,626	18,226,139	15,511,608	
47.1	17.1	26.9	20.5	134.0	114.1	528.4
94.3	34.2	53.8	40.9	278.0	228.0	1066.2
141.4	51.3	80.7	61.5	402.0	342.2	1584.6

Table 3. Discharge Measurement at Low Flow-Partial Record Station.

	Number of Years Measured	Average Minimum Flow Cu Ft/Sec/Month	Gal/Day	Area Supported (100% Utilization) Hectares
Fonte River	15	6.27	135,080	4.0
Masso River	11	5.52	118,922	3.5
Faata Springs	13	5.61	120,861	3.6
Taleyfac River	17	21.15	455,653	13.4
Cetti River	8	9.72	209,407	6.2
Lagafua River	23	19.14	412,350	12.1
Piga Springs	21	4.56	98,240	2.9
Astaban River	16	4.35	93,716	2.8
Laelae River	16	17.67	380,681	11.2
Toguan River	25	5.07	109,228	3.2
Siligin Spring	19	1.83	39,425	1.2
Ajayan River	14	8.61	185,492	5.6
Agfayan River	14	20.07	432,386	12.7
Aasamano River	16	28.68	617,879	18.2
Yledigao River	16	28.59	615,940	18.1
Fintasa River	16	23.22	500,249	14.7
Fensol River	16	5.10	109,873	3.2
Asalonso River	25	12.54	270,160	7.9
Agum River (Above Bubulao)	16	82.38	1,774,786	52.2
Bubulao River	16	113.01	2,434,676	71.6
Ugum River	16	213.90	4,608,240	135.5
Manengon River	16	19.11	411,704	12.1
Tolaeyuus River	6	150.78	3,248,389	95.5
Lonfit River	3	43.83	944,269	27.8
Sigua River	3	48.63	1,047,680	30.8
Atantano River	5	28.92	623,050	18.3
Madag River	16	7.47	160,933	4.7

advantages of a relatively stable quality, free of pollutants, and free of unwanted aquatic species.

SPECIES APPLICABLE FOR CULTURE ON GUAM

Guam affords an ideal climate for the culture of warm water species. Year round warm temperatures allow growth to be at its maximum rate with subsequent high yields. For species to be of value to culture on Guam, there would have to be an existing demand or a potential demand located on Guam or within an economical shipping radius (which would have to be defined for each species). The majority of cultured species will be exotic (introduced species) to Guam. It is highly preferable to use species of which the complete life cycle can be controlled. Species of subtropical and tropical orgin are most suited for Guam's climate. Temperate species will often be at their upper limit of temperature tolerance and unsuitable for economic culture due to raised metabolism, thus reducing the food conversion ratio.

In determining which species are suitable for aquaculture, both fresh and marine, the basic criteria is economic feasibility. All other factors, biological, technological, environmental, management, and market demand contribute to determining the economic success of a species.

Aquaculture on Guam inevitably will be limited to a few species that are proven to be most profitable to culture. The limited resources available (land and water)on Guam deters diversification of cultured species due to the economics involved in large scale culture, namely labor costs, optimum design for containment of a species (including a hatchery), processing costs, and market establishment.

Aquaculture can be divided into the raising of aquatic organisms caught from the wild, which would be called fish farming, and a second catagory, fish culture, which would be the raising of aquatic organisms through their entire life cycle in captivity. Aquaculture practises involving low stocking (from wild stock), low capital investment, no or minimal control of the aquatic environment, no supplemental feeding, little or no fertilization, low production/area, and being labor-intensive are considered extensive aquaculture practices. This type of aquaculture is common in underdeveloped countries throughoust southeast Asia. At the other end of the managerial spectrum in aquaculture is intensive aquaculture, which involves supplemental feeding, control over the complete life cycle, maximum control of the aquatic environment, high stocking density, high production/area, and is capital intensive. This paper deals mainly with the latter.

Aquaculture is similar to agriculture in that a selected species or group of species are confined to a given area from which a maximum production is obtained by the application of fertilizers, feeding, disease control, environment quality management, and control of predation. Biological and technological factors favoring intensive culture of a species have a low trophic level, (efficient food conversion), disease resistance, gregarious nature, rapid growth rate, control of the complete life cycle, high fecundity and survival, and hardy nature. A reliable source of juveniles is a necessity to a successful aquaculture business. This , in most cases, would necessitate knowledge of propagation and rearing of larval stages in a hatchery, since total reliance on wild stocks will result in unpredictable production.

Freshwater organisms

Macrobrachium rosenbergii

The giant Malaysian prawn (*Macrobrachium rosenbergii*) is endemic to the southeast Asia and Indo-Pacific area, with its furthest northeastward extent being to the Pålau Islands. Preliminary work on culture of *M.*

rosenbergii was done by Ling (1967) with subsequent investigation into the mass cultivation of the larvae by Fujimura (1970). Culture of this species is practiced in S.E. Asia, United States, Mexico, South America, Philippines, Micronesia, South Pacific, Taiwan, and Japan.

This is one of the most thorough scientifically investigated species with the intent of optimizing knowledge of its culture. The majority of the research has been carried out in the U.S. This extensive information contributes to the desirability of this species for cultivation, along with characteristics of complete control of the life cycle, relatively free of disease, suitable for polyculture, luxury product demanding premium prices, omnivorous feeding habits and applicable to intensive or extensive culture.

The production capability of this species on Guam is 4637 kg/ha/year (FitzGerald, 1975). This is based on the harvest of two crops per year. This production was carried out in a stagnant pond (no water discharge, only maintenance of water level). Supplemental feeding of a commercially prepared food, turkey starter (28% protein), was used. The use of a polyculture system is recommended, with Chinese carp being the secondary species. As with other crustaceans the occurrence of molting in the pond makes the prawns vulnerable to cannibalism; however, this can be minimized by providing numerous shelters.

At present the entrepreneurs engaged in the culture of this species on Guam receive post-larvae for stocking from the Hawaii Fish and Game Department through Guam's Division of Aquatic and Wildlife Resources at no cost, except for air freight charges. Hawaii has set a limit in the past of one million post-larvae (sufficient for stocking 5 hectares) as the maximum it can supply Guam. As Hawaii's prawn industry has grown its ability to supply Guam with post-larvae will terminate. A hatchery will have to be developed on Guam and a temporary alternate source of post-larvae found (e.g., Palau) to sustain existing farms and to meet the demands of the growing industry. Sixth the addition of a hatchery for prawns on Guam, the management and production capabilities will increase. Year round production of post-larvae will allow the use of a staggered stocking method which can increase production and allow a continuous supply of harvestable prawns to be available. Guam imports an estimated 500,000 pounds of shrimp per year. Production of *M. rosenbergii* could fill a large portion of this local market demand. Japan presents an enourmous foreigh market for prawn and fishery products with premium prices paid for 16-20 prawns/pound size.

Anguilla japonica

The freshwater eel *Anguilla japonica* is a catadromous species with the migration of mature eels to the sea for spawning and the return of the elvers to rivers. It is at this point that the elvers are captured and held before stocking in grow out ponds. All pond culture of this species is dependent on this capture of wild stock. Progress has been made on the artificial propagation of *A. japonica*, but it is still only on an experimental bases. The source of juveniles for stocking are Mainland China, Korea, Taiwan, and Japan, with the later two countries usually not being able to meet their own demand. There is the possibility of substituting a similar Australian - New Zealand species, *Anguilla australis*, since the supply of wild elvers is not always available in adequate quantity from the previously mentioned coutries. Other species suitable for culture are the European *A. anguilla* and the American *A. rostrata.*

Culture of this species is intensive and usually as a monoculture. The eels are carnivores by nature, but are fed on a commercially prepaired balanced diet. Production varies with the method used from less than 1 kg/ m^2 in earthen ponds up to 60 kg/m^2 in concrete environmentally controlled tanks. Guam's Aquatic and Wildlife Resources' experimental eel culture was on a polyculture basis in a earthen pond. Growth was shown to be very rapid under the warm water conditions, with harvestable size obtained as early as after 4 months of culture. A key factor in good production results of this species is the ability to have close management control. This is mainly needed for the required sorting of size classes during the grow out phase, in addition to disease prevention, and observance of the general condition of the eels which is usually evident in feeding behaviour.

Guam has one entrepreneur engaged in eel culture. This is with the use of concrete walled ponds with an area of 2 hectares which will be expanded with future demands. The expected production from these ponds will be 100 mtons/year. The major market for the eels is Japan. There is a small local market, but future expansion of eel culture will be solely for an export market.

Pangasius sutchi

The S.E. Asian catfish *Pangasius sutchi* is generally grown as a monoculture, but polyculture can be used with suitable species (e.g., carp). They live in rivers, and lakes, and can be raised in ponds or cages. They will not reproduce in ponds since they require moving water for reproduction to occur. This fish has great potential for Guam due to its capability of high production per unit area (e.g., 75,000-95,000 kg/ha/year) (personal communication, Nukit). The species is omnivorous and is usually fed on a mixture of vegetable matter and fish. The main draw back to their production on Guam is the requirement of 20% or greater protein in their diet to obtain the desired growth rate. They also require a high feeding rate of 10-12% body weight/day. This necessitates an abundant supply of an inexpensive food source to fulfill dietary requirements. Possible areas of a cheap food source would occur with the development of a proposed vegetable cannery, livestock slaughter house, tuna cannery, or utilization of activated sludge from the waste treatment plants. The initial cultivation on Guam by the Division of Aquatic and Wildlife Resources met with unfavorable results which were mainly attributed to improper diet and the competition for food with Tilapia. There is a breeding stock being held at Aquatic and Wildlife Resources for future artificial propagation.

Clarias (Clariidae)

Clarias (C. batrachus, C. macrocephalus, and C. fucus) are other southeast Asian catfish that offer high production per unit area (80,000-90,000 kg/year/ha). They are easily bred in captivity, of hardy nature, and feed on a wide variety of vegetable and animal matter. C. batrachus is favored for culture through southeast Asia due to its more rapid growth rate. C. batrachus occurs on Guam and is usually found in swampy areas that are subject to drying up during periods of low rainfall. It has the characteristic of having an accessory air breathing organ that enables it to exist in oxygen poor waters and to leave pondages in search of food. The advantages of the ability to withstand low oxygen waters is obvious; however, its ability to leave a body of water and move across land requires precautions. It has the ability of burrowing into the mud to survive extensive dry periods. Due to this ability, a pond used for this species should not be altered with the culture of species that might become prey of the catfish (e.g., prawns), since complete eradication from a pond would be difficult as the result of their ability to burrow into mud. A possible solution to this would be a concrete tank culture system. The culture of these catfish would require a fencing enclosure around the pond to prevent escape. *Clarias* is presently imported to Guam's fish markets. The Division of Aquatic and Wildlife Resources is examining the feasibility of the commercial culture of *C. batrachus* on Guam.

Chinese Carp

These fish are mainly recommended on Guam as a secondary species to increase overall production by more fully utilizing the three dimensional space of the pond, and help maintain a balanced pond environment. Grass carp (*Ctenopharyngodon idellus*) are herbivores that help control grasses growing along the pond banks. Silver carp (*Hypophthalmichthys molitrix*) are microphagos herbivores, feeding on the phytoplankton. Big head carp (*Aristichthys nobilis*) are microphagos carnivores, feeding on zooplankton. Common carp (*Cyprinus carpio*) are detritus feeders. At present, stock is obtained from Taiwan, but they can be artifically propagated on Guam once a breeding stock is established.

Tilapia sp.

This genus of fish has a variety of feeding habits, but in general is an aggressive opportunistic feeder. They breed naturally at a high rate in ponds, thus overpopulating, causing a general reduced growth rate, and a crop of an unsuitable size mixture for marketing. Monosex culture would be the only suitable means of culture on Guam. This is done by the crossing of species to produce a hybrid progeny of all males, or by hormone in the feed of sexually indetermined fry to produce an all male population. In general, Tilapia are an invader species (often interfering with the culture of highly valued species) and are hard to eradicate from ponds where they are not desired. Their aggressive feeding takes food away from the desired cultured species. Tilapia would be suitable for use in stabilization ponds where they would feed on the natural productivity of the pond. It's low on-island market value would eliminate the desire to be cultured on a large commercial scale on Guam, unless market changes are made through product promotion. The catering to the Japanese tourist resturants with a live product to satisfy culinary tastes would support a limited production.

Soft Shell Turtle

The soft shell turtle (Trionyx sinensis) is a high-priced item that is considered a delicacy in Taiwan and Japan. Its culture is carried out in ponds with concrete or stone walls with an overhang to prevent escape. T. sinensis are mainly fed on trash fish and animal products. Growth of the turtle normally takes approximately two years before it reaches a harvestable size (600 g); however, this growth period could be reduced to about one year on Guam due to its favorable climatic conditions. Stocking varies according to the size of the turtle, and size segregation must be practised to prevent cannibalism. Reproduction occurs in special rearing ponds in which mature turtles (3 years or older) are placed. Egg laying occurs in a small brick enclosure with a sand floor. Hatching takes approximately 50 days.

Soft shell turtle culture on Guam was initiated on a small scale by a private entrepreneur. The initial venture proved unsuccessful due to an inadequate enclosure to prevent escape. A second entrepreneur has constructed three small ponds (7 m x 17 m) for the culture of turtles and carp. The marketing will be mainly in Taiwan. This is a rather limited culture for a special market.

Bait Fish

A key factor in the development of skipjack tuna fisheries in this area of the Pacific would be a suitable supply of bait fish. A number of species have been considered and used as bait fish including Tilapia mossambica, Dorosoma petenense, Poecilia vittata, Poecilia mexicana, Sardinella melanura, Engraulus japonicus, Chanos chanos, Kuhlia sandviciensis, mullets, and cyprinids (Gopalakrishnan, 1976). Live bait pole and line method of catching skipjack tuna is the most productive means at present for harvesting skipjack. Large purseseining boats have not proved to be viable in this area of the Pacific to present.

Important factors influencing the selection of a suitable bait fish are: to be prolific, continuous breeding, gregarious, of good growth rate, hardy (both in culture and during holding in bait wells), show suitable behavior, size, color, and shape to attract tuna, and must be accepted by fishermen for use. A promising genus that is presently being worked on in Hawaii and American Samoa is Poecilia (Baldwin, 1974; Swerdloff, 1973). This genus is suited to mass culture (Baldwin, 1972).

Brackish Water and Saltwater

Chanos chanos

The milkfish or sometimes called bangus (Chanos chanos) is a euryhaline fish with a tolerance of 0-35 ‰. It has been cultured on Guam on a small scale in freshwater by Aquatic and Wildlife Resources (FitzGerald, 1975), and in salt water by a group of Filipino workers. There is no means of artificial propagation at present. All stock must be caught from the wild. The closest possible supply of milkfish fry at present is Palau or Yap; however, their runs are too unpredictable in quantity and time to be a dependable source. Runs of fry have been reported on Guam but are too few and unpredictable, also. The major area of abundant milkfish fry runs is in the Philippines; however, they have enforced a moritorium on the export of milkfish fry. Until artificial propagation can be practised with this species or a stable supply of wild stock is established, further pursuit of the culture of this species on Guam would be futile.

Grey Mullet (Mugilidae)

The mullet is a marine species of fish, which enters estuaries and the lower extents of rivers. The salinity tolerance is similar to the milkfish in that they can adapt to freshwater or saltwater. Their distribution is wide spread with Mugil cephalus (the preferred species for culture) being a circumtropical species. Some of the favorable characteristics of this species are euryhaline 0-38 ‰, eurythermal 3-35 C, low trophic level (herbivore), and high quality flesh. M. cephalus naturally reproduces in salt water, but artificial propagation has recently become successful on a practical scale (Shehadeh and Norris, 1972).

Cultivation of mullets is usually in brackish water ponds, where they feed on plankton (both zoo and phytoplankton), benthic algae, and detritus. They also accept artificial feed. Growth varies with density of stocking and feeding from 200-500 g in one year. They can be raised as a monoculture, but more commonly are raised in a polyculture situation. On Guam, their culture would be mainly as a secondary species, filling a niche that the primary species does not occupy. Mullets are stocked at low densities. Their low production per unit area will eliminate their desireability for large scale culture on Guam.

Scylla serrata

The mangrove crab (*Scylla serrata*) is an extremely territorial and aggressive species which makes its economic culture very difficult. It is a high valued product, but the low production capability per unit area, under present culture methods, makes its cultivation unlikely for Guam. It does occur naturally on Guam. An unsuccessful small scale culture was attempted by Aquatic and Wildlife Resources in conjunction with one of the commercial pond operators, and a basic growth and natural history study was done at the Universtiy of Guam Marine Laboratory (Dickinson,1977).

The ability to culture *S. serrata* through its larval stages is known (Ong Kah Sin, 1964). A culture of this crab on a capital intensive rather than labor intensive scale is presently not practical. Developments along this methodology, which would be similar to that of the American lobster (*Homarus americanus*), is possible in the future. Its culture in Asian countries is on an extensive basis, and is usually only held for a short fattening period after its capture from wild stock before being marketed. Its commercial pond culture prospects being of significant importance is unlikely (Ong Kah Sin, personal communication).

Crassostrea gigas (Oysters)

An experimental culture of C. gigas was conducted at various locations around Guam by Aquatic and Wildlife Resources (FitzGerald, 1975). The general lack of biologically rich marine waters around Guam makes the culture of filter feeding organisms less productive than areas of productively rich waters. The Apra Harbor area appears to be the only feasible site around Guam for oysters or other filter feeding bivalves on a large commercial scale. Some of the sheltered small bays may afford a suitable area for a family consumption type of culture.

Mytilus (Mussels)

This bivalve mollusk is one of the most efficient feeding animals. It has a rapid growth rate with a high nutritional value, and excellent palatability. Mytilus culture would be limited to the same areas as oyster culture, namely the Apra Harbor area. The major means of culture would be raft culture.

Penaeid Shrimp

A number of penaeid species are suitable for culture; however, Penaeus monodon (the Philippine sugpo) along with P. japonica would probably be the most desired. Penaeid culture is usually carried out in tidal ponds. The filling and emptying of the ponds are correlated to the spring and neap tides. The maximum difference of a tidal cycle on Guam is 3.5 ft. This would be a limiting factor in the ability of this culture method. Utilization of pumps for water exchange would be necessary. Gravid females are usually caught from the wild, with the subsequent raising through the larval stages to post-larvae in captivity. Development of bringing about maturation and ovulation in captivity by eye stalk ablation is being refined so the whole life cycle can be completed in captivity.

Siganids

Rabbitfish (*Siganus spinus*, and *S. argenteus*) are very popular reef fish on Guam and throughout Micronesia. There is a wild stock available on Guam. In addition, artificial propagation is known (Bryan,et. al., 1975). *S. spinus* and *S. argenteus* are the two species that usually have large juvenile runs on Guam (Kami, 1976). Preferably *S. argenteus*, due to its better growth rate, would be stocked into ponds or enclosed areas of the reef or floating cages (Tsuda, et. al., 1976). The major drawback to the culture of this species is obtaining an economical food source that will produce an acceptable growth rate. Conditions for the culture of the prefered alga food for this species is known (FitzGerald, 1976), but supplemental protein has to be added to the diet to obtain rapid growth.

Grouper, Sea Bass, and Snapper

These species (*Lutjanus argentimaculatus*, *Lates calcarifer*, and *Epinephelus tauvina*) are suited for cage culture. They are high valued species. They are carnivores and require an inexpensive supply of scrap fish. This is the main deterent to culture of these species on Guam. If a tuna cannery or fishing industry develops on Guam, a possible cheap source of protein would be available. The complete life cycles of these species have been acheived in captivity (Wongsomnuk and Brohmanonda, personal communication).

Algae

Commercial culture of algae would be very limited due to the restriction on available areas that would be feasible for its culture on Guam. The only areas that would afford adequate protection from storm damage to crops wouldbe Apra Harbor and Cocos Lagoon. There is no developed local market so all of the production would have to be processed for export. Genera that could be used for culture on Guam would include *Eucheuma*, *Gracilaria*, *Gelidiella*, *Caulerpa*, *Porphyra*, and *Enteromorpha*. *Eucheuma*, *Gracilaria* and *Gelidiella* could be used in marine colloid production. *Enteromorpha*, *Gracilaria*, *Porphyra*, and *Caulerpa* could be used as human food. The use of alga as an animal feed (e.g., *Enteromorpha* in Siganid culture) could be feasible, but would be most economically based on the utilization of a waste nutrient source (e.g., effluent from pond culture). Various other genera have been used as cattle fodder (Jensen, 1972).

Present methods of algal culture are mainly labor-intensive. This will discourage its development on Guam until an efficient economically capital-intensive means of culture becomes viable. As for example an annual net income from a family-operated 0.5 hectare labor-intensive *Eucheuma* farm in the Philippines is $1360 (Deveau and Castle, 1976). Guam would be incapable of competing on a world-wide marine colloid market with such competition from labor-intensive countries. Capital-intensive methods of growing *Eucheuma* are being examined in Florida, but have not yet proven economically viable (Deveau and Castle, 1976).

FACILITIES FOR AQUACULTURE

Ponds

Earthen pond culture is the oldest and most widespread means of containing cultured species. Ponds vary greatly in size from less than 0.1 ha to over 40 ha. This depends greatly on the species being cultured, the intensity of the culture, and the terrain. The present general trend is towards smaller ponds (e.g., 0.1-1.0 ha ponds) since they afford closer management practices. Earthen ponds are constructed by the excavation of the soil from the pond area to form dikes. Heavy equipment (bulldozers and backhoes) should be equiped with LGP tracks (low ground pressure) since most ponds are constructed in areas consisting of soft soils. Conventionally equipped machinery would frequently become stuck or inoperative. As the soil is excavated and placed along the dikes it is firmly packed so that the bank does not allow leakage or possible breakage due to insufficent compaction. The soil should be free of vegetation, roots, and large rocks. It is preferable to minimize alteration as much as possible of the bottom and banks that are formed naturally by the terrain, since this soil is already compacted and less likely to allow seepage or breakage.

The actual lay-out of the ponds depends on the terrain. In V-shaped slightly obliquely truncated valleys, small diversion ponds can be constructed. In rounded off V-shaped valleys, barrage ponds or a series of linked diversion ponds are constructed. In V-shaped valleys that are slightly horizontally truncated, strongly truncated or totally truncated the use of linked or parallel diversion ponds is recommended (Huet, 1970).

The type of soil the pond is constructed of is crucial. The soil must have the characteristic of water retention. This usually requires a minimum clay content of 25%. Fertile soils are naturally preferred, but marginal soils that are unsuitable for agriculturial use can be utilized by the addition of fertilizers and lime (acidic soils). Mineral content of the soil should be examined. A high salt content can be deleterious to the culture of some species. Previous use of the land should be known. If pesticides were used the area may be unsuitable or require considerable leaching to remove the pesticide residue.

The width of the dikes depends on their use other than retaining the water. If vehicle access is required the width should be at least 6 m at the base and 3 m at the berm. Dikes separating ponds running parallel to each other can be of a reduced width if they are not intended for vehicle passage.

The slope of the banks varies according to the size of the pond. For ponds of the 0.1-1.0 ha size, an inside slope of 1:2 and an outside slope of 1:1 is recommended. Larger ponds require a 1:3-1:4 slope. The main purpose of sloping the banks is to reduce erosion of the banks by water movement. The dike height should be at least 30 cm above the surface of the pond water. Water level inside the pond should be 0.7 to 1.2 m deep. Historic review of maximum flood water height should be made, with the subsequent construction of the dike height to prevent entrance of flood waters into the pond. The addition of a grass with good soil retaining capabilities is also recommended as a cover and soil binder to extend the life of the banks. The planting of vegetation with large woody root systems is discouraged since this weakens the dikes and facilitates leakage.

The pond bottom should have a slope of 0.2 to 0.5% towards the drain.

It should be uniform in construction with no pot holes or roots remaining. It should also be compacted if possible while being bulldozed. A collection basin may be constructed at the drainage site. This basin should not exceed 10% of the pond area. The pond should be capable of complete drainage to facilitate eradication of undesired species, control of disease problems, and mineralization of the bottom soil.

Water addition to the pond is done at the end opposite to the drain. Dispersion of water is in a manner to prevent erosion of the bank and bottom. Aeration is accomplished by splashing or spraying the water as it enters the pond. The water source should be screened sufficiently to prevent introduction of unwanted species. It should be free of pollution, also.

Drains (e.g., sluice gate, monk, stand pipe) also vary in design and construction. However, the basic functions are to control water level (overflow), prevent escape of cultured fish (also introduction of undesired species from drainage canals), and to allow complete drainage of the pond. The preferred flow of water out of the pond is in such a manner that the bottom water is drained. Each pond should have its own drainage system that empties into a drainage canal. It is ill-advised to link ponds through the drainage, since this decreases management efficiency, and also increases the possibility of spreading of disease through all the ponds.

Culture of species in impoundments where a stagnant water flow method is used would impose the least direct burden on the environment due to its limited discharge (except during complete harvest). In addition it requires the least amount of water resources to maintain the system.

Flow-through systems for species requiring a very high water quality or so intensely stocked that a continual flow is necessary to maintain basic water quality requirements would be a means of culture that adds a continual and often substainal quantity of waste water.

Raceway Culture

Raceways are designed to allow a continuous large flow of water through the enclosure to facilitate flushing of wastes, maintenance of high oxygen levels, and in the case of circular designed raceways, the movement with the current of species of fish that tend to continually swim. Raceways are commonly used in trout and channel catfish (Ictalurus punctatus) culture. Due to the high water quality maintained in raceways, the stocking density is greater than that used in ponds, thus giving a higher production per unit area.

The application of a raceway to the culture of aquatic organisms can be diverse. Culture of filter feeding organisms (e.g., oysters) is feasible with the introduction of a water source containing a high density of planktonic food organisms. The system can be of an open or closed circulation type with flow rates suited to optimize delivery of food organisms, removal of waste products, and maintenance of desired oxygen level. The practice of polyculture is feasible within a raceway system as demonstrated by Ryther (1975) in the production of fish (Pseudopleuronectes americanus), shellfish (Crassostrea virginica, Mercenaria mercenaria), lobster (Homarus americanus), and macro-algae (Gracilaria foliifera, Agardhiella tenera) within a raceway system.

Raceway culture is a sophisticated capital intensive means of aquaculture. Its use on Guam could be applied to both fresh and marine-cultured species. However, the requirements of large water volume flow through a raceway would limit its use, especially for freshwater, unless the water is filtered and recycled.

Floating Cage Culture

This method of culture originated in Cambodia and has spread throughout the Mekong River system. Modified versions are used in the culture of numerous species both in fresh and marine waters throughout the world.

Cage culture allows the utilization of an existing body of water (lake, river, ocean) for the culture of species that will tolerate intense stocking in a confined space. This method of culture has the advantage over pond culture of usually requiring less initial capital investment. Operational expense can also be less (e.g., no water pumping expense); however, the life expectancy is less than that of a pond. Frequent cleaning of algae growth from the cage is necessary to prevent obstruction of water circulation which is necessary to flush wastes and renew oxygen levels.

Greater stocking densities are usually practiced in cages than ponds. Thus a species to be suitable to this type of culture must tolerate crowding. Examples of species that are used in cage culture are *Pangasius sutchi*, carp, sea bass,grouper, and red snapper.

The sizes of cages vary from a cubic meter to 625 cubic meters, which are essentially floating cages upon which the entrepreneur lives in a hut. A practical size range for use on Guam would be 10 m^3 to 200 m^3. A cage can be constructed of a number of materials, but the type that would be suitable to Guam would basically consists of a framework forming the structural shape of the cage, around which a netting material is attached to form the enclosure. This structure is attached to floating devices, or fastened to poles secured into the substratum where a tidal fluctuation does not occur. The net must extend beyound the water surface sufficiently to prevent the escape of the fish or introduction of undesired species. In cases with species that tend to jump (e.g., *Pangasius sutchi*) netting must be extened over the top.

On Guam, the utilization of cage culture can contribute very substantially to the total aquaculture production. For example, obtaining the use of a portion of Fena Lake for the purpose of fish cage culture would be a productive means of utilizing an existing asset. Possibly, a cooperative venture could be arranged with the Navy, who controls the lake. In addition, it could be used to augment production within dammed areas adjacent to large fish culture operations. This culture method would be very applicable to marine species also. In most cases this being the preferred means, since it does afford a higher degree of management as compared to penning in an area of a reef flat. However, the use of cages in the marine waters would require that they do not obstruct passage of vessels. Areas where this might be practiced would be Apra Harbor and Cocos Lagoon.

Raft and Stick Culture

Raft and stick culture methods are used for oysters and mussels. Stick culture being limited to shallow water. Oyster spat that have settled on collector shells are attached to a stick which is anchored into the substratum. This method of shellfish culture is susceptable to predation by benthic organisms and aerial exposure due to tidal fluctuation.

The raft culture method is more productive per area and a more manageable means of culture. This consists of a raft constructed of crossmembers (usually wood) which are floated (e.g., attachment of 55 gallon oil cans). From the crossmembers are hung the culture lines. The materials used for construction and design vary.

ENVIRONMENTAL IMPACT DUE TO AQUACULTURE PRACTICES AND POLLUTION ABATEMENT MEANS

Intensive culture of aquatic species within ponds or other enclosures with the addition of fertilizers and supplemental feeds results in the production of large quantities of waste products both directly from the cultured species and from biological activity associated with this eutrophic environment. The discharge of this effluent into receiving waters can be a considerable pollution source, if not properly managed. Since the pond can be considered as a point source of eutrophication, pollution abatement measures must be designed into the system. The costs of these abatement measures can become the limiting factor in the viability of an operation and deserves careful examination by the entrepreneur. Three broadly grouped categories of polluting factors from the effluents of fish culture activities are recognized (Hinshaw, 1973). The first category includes the passing of pathogens and parasites into natural waters from hatcheries or ponds. The close proximity of species during culturing facilitates the transmission of disease. A second category is the prophylactic or therapeutic use of chemicals and drugs to control diseases and parasites. These can be introduced directly into the impoundment or through the feed. The third group are factors that affect the chemical or physical water quality of the recieving waters. Metabolic wastes from the fish, unused food, algae, and detritus from ponds can have adverse affects on the receiving waters. Increased biochemical oxygen demand, carbon dioxide, ammonia, nitrate, and nitrite levels would be associated with this effluent. The dissolved and suspended solid level would also contribute to the pollution factor of the effluents.

Water pollutants may alter natural conditions by reducing the dissolved oxygen, by changing the temperature, or by direct toxic action that can be lethal or more subtly, can affect the behavior, reproduction, and physiology of the organisms. Although a substance may not directly affect a species, it may endanger its continued existence by eliminating essential sources of food and metabolics. Furthermore, conditions permitting the survival of a given organism at one stage of its life may be intolerable at another stage.

Physical alteration of the environment during construction and the resulting physical structure of aquaculture ponds can cause a lasting effect on the biological community by altering water flows and circulation, especially in estuary areas where blockage of large sections can prevent flushing (Odum, 1970; Copeland, 1968). Effective planning to allow for natural circulation is needed or the addition of an artificial circulation. Alteration or destruction of estuary areas, that may serve as a nursery for numerous species, may secondarily affect sport or commercial fisheries by reducing the natural stock. As with any construction envolving the grading or moving of earth the potential for sedimentation is increased.

Pollution Parameters

Water pollution is defined by Warren (1971) as any impairment of the suitability of water for any of its beneficial uses, actual or potential, by man-caused changes in the quality of the water. A more workable definition, limiting effluent discharge, is used by the Guam Environmental Protection Agency as the water quality below the discharge point must be equal to or better than that above the discharge.

Parameters and their effects contributing to water pollution of the receiving waters of fish pond effluent are as follows:

Nitrates

Nitrates are the most highly oxidized phase in the nitrogen cycle. They can reach high concentrations during biological oxidation. High concentrations are indicative of organic pollution. Nitrate concentration in natural waters usually ranges from 0.5-5.0 PPM (Hutchinson, 1957). Nitrates are the most usable form of nitrogen for plant growth. Generally an increase in nitrates is followed by an increase in algal production and an increased productivity of the whole ecosystem. However, an increase of nitrate level beyond 20 PPM has detrimental effects for fish culture (Spotte, 1970).

Nitrite

Nitrite is an intermediate of the nitrification process (ammonia-nitrite-nitrate). It can accumulate during the development of nitrifying activity, due to elevated ammonia levels, or when the normal nitrification path is interrupted, for example, by addition of chemotheraputics to the water. Nitrite can be toxic to fish by means of reducing oxygen transport efficiency of the blood resulting in hypoxia in extreme cases. The nitrite oxidizes hemoglobin to methemoglobin which is incapable of releasing oxygen on demand (Smith and Russo, 1975). Lethal levels for nitrite range from 0.14-0.55 mg NO_2-N/l (Forster et.al., 1977). Concentrations as low as

0.096 mg/l NO_2 showed a small, but significant increase of methemoglobin in trout which were exposed for 8 days (Smith, 1975). A LC 50 of 0.23 mg NO_2-N/l was found for trout (Brown and McLeay, 1975).

Ammonia

Ammonia originates from mineralization of organic substances by bacteria and from excretion by fish. Unionized ammonia is very toxic to fish and should not exceed 0.1 PPM. Toxicity varies by the concentration of undissociated ammonium hydroxide in the water, which in turn is a function of the pH and temperature. Spotte (1970) notes that even at sublethal levels ammonia will have four adverse effects to fish populations: (1) increased susceptibility of fish to other unfavorable conditions such as low oxygen, (2) inhibited normal growth, (3) decreased fecundity, and (4) decreased resistance to disease. High levels affect the gill tissues and reduce the ability of hemoglobin to combine with oxygen. High, but nonlethal, ammonia concentrations will cause extensive proliferation of eithelium which prevents normal respiration (Smith, 1972). Spotte (1970) sites chronic ammonia levels as the most serious problem that the fish culturist must deal with.

Settleable and Suspended Solids

Settleable solids and suspended solids can be organic or inorganic in origin. They have a greater effect on fish populations in a natural environment than in fish ponds where artificial feeding occurs. Light penetration would be limited, thus reducing algal growth which is the basis for the food chain. In aquaculture, the suspended solids may cause a buildup of sludge on the bottom, consisting mainly of the remains of plankton which decompose and increase the BOD in the pond. High loads of suspended solids may cause gill tissues to be affected and should remain below 80 PPM for optimum health in fish culture (Wedemeyer and Wood, 1974). The composition of suspended particles in surface waters are important because of their effects on light penetration, temperature, soluble products, and aquatic life. The mechanical or abrasive action of particulate material is of importance to the higher aquatic organisms, such as mussels and fish. Gills may be clogged and their proper functions of respiration and excretion impaired. Blanketing of plants and sessile animals with sediment as well as the blanketing of important habitats, such as spawning sites, can cause drastic changes in aquatic ecosystems. If sedimentation, even of inert particles, covers substantial amounts of organic material, anaerobic conditions can occur and produce noxious gases and other objectionable characteristics, such as low dissolved oxygen and a decrease in pH. Odum (1974) sites the increase of sedimentation under rafts, mainly due to feces and pseudofeces, in the case of oyster culture.

Biochemical Oxygen Demand

Biochemical oxygen demand is the quantity of oxygen required for the biochemical oxidation in a given time at a given temperature of organic matter. The introduction of effluent with a high BOD into a stream puts an excess burden upon it. This type of pollution can be very destructive when relatively large amounts of putrescible organic materials, which require oxygen for their decompostion, are introduced into the waters. The oxidation is dependent upon the availability of dissolved oxygen in the waters and the ability of the body of water to maintain this oxygen level above the BOD through exchange with the atmosphere and the photosynthesis of algae.

If the dissolved oxygen falls below that required by the BOD loading, anerobic conditions arise.

Toxins

Since we are dealing with the culture of organisms, the use and occurrence of toxins are avoided. Usually the only time a toxin is introduced into a pond is after drainage. However, a class specific toxin may be used during culture to rid the pond of pest species (e.g., fish from prawn culture ponds). A fish toxin may be introduced to eliminate undesirable species that may remain in small bodies of water or the mud/water interface. This should be held in the pond for the prescribed period of time for deactivation of the toxin before refilling or further discharge. The addition of chemical oxidants can speed up this process. Careless use of the toxins with its entry into the receiving waters can cause large fish kills. Trained personnel should be available for supervision during the administration of toxins. Toxins from tank culture systems can include algacides, and chemicals used in cleaning the tanks.

Coliform

The quantity of coliform bacteria is a standard means of indicating pollution levels. Coliform bacteria (Escherica coli and similar gram negative bacteria) are normal inhabitants of fecal discharges from warm blooded animals. Total coliform counts can be misleading since certain coliform bacteria occur naturally associated with various vegetation. The Guam Water Quality Standards specifies fecal coliform counts as a standard testing of Guam's waters for pollution. The presence of fecal coliform is used to indicate a degree of pollution (possible presence of human pathogenic organisms) in waters; however, since fecal coliform is restricted to warm blooded animals this is not relevant as a pollution indicator from fish ponds. As previously mentioned, the use of a total coliform count also is not a reliable indicator of pollution since certain species of coliform bacteria occur naturally in the environment. Certain coliform bacteria are part of the natural nitrification process, and most likely due to the increase in ammonia (metabolic waste) within fish ponds, the presence of this coliform bacteria will increase.

If it were possible to monitor a common intestinal bacteria restricted to fish, this would be more suited as a pollution indicator from fish ponds than fecal or total coliform counts. The monitoring of other parameters (e.g., ammonia, nitrate, phosphate) will be a more useful guide to the degree of pollution a fish pond contributes to the receiving waters.

Study of Hatchery and Pond Effluent

A study conducted at six hatcheries in the United States showed a degradation due to hatchery effluent of the receiving waters (Hinshaw, 1973). Of the parameters tested, ammonia (major nutrient contributing to the effluent), BOD, MPN coliform, and suspended solids were the factors contributing significantly to a change in the receiving waters. A correlation was found with the water quality above the discharge point to that below. A high quality water showed degradation less than in water of lower initial quality. Waters with a high degree of enrichment prior to use resulted in hatchery effluents that were considered a possible public health problem. Contrary to this, waters of high quality, prior to hatchery use did not significantly degrade receiving waters below the discharge point. In general, hatchery effluents showed a significant increase in MPN coliform counts, which could pose a potential public health hazard (Hinshaw, 1973). BOD levels were increased significantly, which were mainly attributed to the use of animal offal or wet feeds that were not consumed. The enrichment of the receiving waters by hatchery activities has increased the growth and propagation of many fish food organisms and supplementally increased the fish population supported by the waters. This could be considered a desirable affect depending if the species of fish were of use to a sport or commercial fisheries. However, the number of pollution intolerant benthic species tended to decrease. In contrast, the organic enrichment from a water quality and public health stand point may not be desirable.

Data recorded by Aquatic and Wildlife Resources (FitzGerald, 1975) for the parameters of nitrate and phosphate sampled from their demonstration ponds and the water supply source (Talofofo River) indicate a significant ($p = 0.05$) increase in phosphate in the pond waters over the river water supply source (Table4). However, nitrate levels showed no significant increase, and actually a slight decrease (not significant) in pond 2 as compared to the river. This lowered nitrate level reflects its uptake by the phytoplankton and macroalgae populations within the ponds. Pond 2 illustrates to a certain extent the efficiency of the use of a stabiliaztion pond in pollution abatement. The operational proceedure of Aquatic and Wildlife Resources personnel was to supply pond 2 with sufficient water to maintain the water level by siphoning water from pond 1. Occassionally, when additional water was needed or adverse conditions arose within pond 2

Table 4. Nitrate and Phosphate Values from Aquatic and Wildlife Resources Experimental Ponds and Talofofo River (FitzGerald, 1975).

	Pond 1		Pond 2		River	
Date	mg/l Nitrate	mg/l Phosphate	mg/l Nitrate	mg/l Phosphate	mg/l Nitrate	mg/l Phosphate
10/1/74	0.200	0.300	0.140	0.240	0.430	0.192
10/8/74	0.360	1.200	0.260	0.330	1.230	0.470
10/17/74	0.150	0.730	0.120	0.310	0.170	0.320
10/21/74	0.140	0.290	0.060	0.240	0.210	0.190
10/30/74	0.330	0.800	0.070	0.340	0.330	0.640
11/4/74	0.940	1.390	0.210	0.410	0.820	0.530
11/20/74	0.222	0.258	0.249	0.444	0.167	0.228
12/3/74	0.610	1.529	0.249	0.944	0.167	0.159
12/20/74	0.360	0.241	0.167	0.797	0.222	0.228
1/3/75	0.332	2.133	0.277	1.084	0.250	0.334
3/10/75	0.332	1.588	0.222	0.419	0.111	0.119
4/4/75	0.279	0.719	0.580	0.211	0.049	
5/4/75	1.387	2.280	1.218	0.419	0.775	0.089
n	13	13	13	13	13	13
$\bar{x}$	.434	1.035	.294	.476	.384	.273

water was pumped directly from the river. The data illustrates a reduction of nutrients (nitrate and phosphate) in pond 2 as compared to pond 1.

Pollution Abatement

Various means of minimizing the impact of aquaculture effluents on the environment are by trickle filters, sand filters, stabilization ponds, irrigation and spraying of crops.

Advanced waste treatment may be physical, biological, chemical or a combination of these processes. Wastes from aquaculture can be treated by the same means as sewage waste water is handled. Biological secondary treatment is the most economical and most satisfactory means of processing waste water (Parker, 1975). Disposal sources of waste water include fresh water, oceans, underground injection, land surface, and reuse.

Trickle Filters

Utilization of trickle filters would be restricted by economics to sophisticated compact aquaculture systems such as hatcheries, raceways, and systems where recycling is used. A trickling filter makes use of a natural cleansing system in which nitrification occurs by biological means (biological oxidation process). It consists of a bed of inert material (oyster shells, gravel, plastic material) on which an aerobic growth of organisms (algae, fungi, bacteria, protozoans, worms, and insect larvae) grow. Waste effluent is trickled from above through the filter. Wastes are removed by the biological community within the filter. This type of filter does not mechanically strain the effluent since the space between the filter media is relatively large (45% of total filter volume) to allow gaseous exchange and rapid flow. Factors influencing the ability of the organisms in the film to assimilate the organic matter depends on the flow rate, organic loading aerobic conditions, and temperature.

Sand Filters

Sand filters, especially slow sand filters, can be used in improving the water quality of pond effluent. A sand filter consists of a layer of sand 2-5 ft deep of 0.25 to 0.35 ml in effective size, underlain by gravel. Drainage is usually be perforated pipes laid under the gravel bed. Flow of the water through the filter is by gravity. Mechanical and biological cleansing of the effluent occurs within the filter. Flow rate is approximately 2.5 million gallons per acre of filter area per day. Higher flow rates can be obtained with pretreatment of the effluent such as sedimentation. The upper layer of the filter after a period of operation (varying with the effluent) must be scraped off to prevent excessive clogging and reduction of the filter efficency. The filtered water can then be recycled to the pond, which reduces its total requirement from the water supply, or it can be drained to the receiving waters if reuse is not desired.

Rapid sand filters require pretreatment of the pond effluent with coagulants (e.g., aluminum sulfate, ferric chloride, ferric sulfate, ferrous sulfate, and sodium aluminate) and sedimentation. Flow rates are 125 million gallons of water per acre of filter surface per day (Ehlers and Steel, 1965). The filter media consists of a gradation in size of sand (0.4-0.8 ml effective size) 20 to 30 inches (50 to 76 cm) thick underlain by 16 to 24 inches (41 to 61 cm) of gravel (1/8 to 2 1/2 inch diameter). The sand filter consists of a tank, the inlet, the underdrain system (perforated collecting pipes) filtering medium, rate of flow controllers, and loss of head gauges.

Spray Irrigation

Spray irrigation systems are designed so they can take primary treated waste water. The water can be taken directly from fish ponds or a stabilization pond. This means of disposing of the effluent is most suitable where agriculture crops and aquaculture are done together. The nutrient enriched waters from the fish ponds serve as fertilization to the agriculture crops with no additional costs thus, best utilizing the resources. This would be a highly preferred method of effluent control from fish ponds. Canal irrigation can be used to augment the spray irrigation for crops for which this method would be preferable.

Stabilization Ponds (Oxidation Ponds)

The employment of stabilization ponds to effluent from fish ponds, prior to its discharge back to the receiving waters, can be an effective means of reducing BOD, nutrient levels, and suspended matter to acceptable EPA standards. The stabilization pond basically consists of an impoundment of water (less than 5 ft deep) that is held for a period of time to allow the breakdown of waste materials through biological processes and a final uptake of nutrients by algae. The period of holding varies with the BOD loading. A decreased holding period can be obtained by added aeration (mechanical) to the waters. Tsai (1975) points out the efficiency of using a final pond for effluents in general. In periods of water shortage this water can then be recycled to the fish ponds.

The basic concept behind the stabilization pond is that it allows the suspended matter to settle; waste material is decomposed and fed upon by bacteria and zooplankton; sludges produced are degraded by faculative anaerobes, including bacteria, protozoa, insects, and worms; nitrification of ammonia wastes products, uptake of nitrates, carbon dioxide and other plant nutrients is done by algae. The further addition of suitable fish species can convert the algae and benthic fauna into a final marketable product (helping to defer construction costs).

In areas where a large quantity of flat unutilized terrain, adjacent to the ponds, exists; it can serve as a simplified evapotranspiration system along with a leaching field of the effluents. However, since land is usually at a premium on Guam this would be an uneconomical use of the land.

Wastewater Addition To Fish Ponds

The use of fish ponds in the purification of sewage water has been noted by numerous authors (Schuster et.al., 1954; Schroeder, 1975; Schroeder and Hepher, 1976; Woynarovich, 1976). Light loads of either organic-rich raw sewage or nutrient-rich biological treatment (secondary) effluent can be channeled through aquaculture systems which would essentially be an extension of the waste treatment process and simultaneously derive an economic benefit. Limiting factors to the use of aquaculture in waste treatment would be the presence of toxic chemicals, petroleum, metals, and pathogenic organisms above an acceptable level. Properly treated (filtered, settled, and diluted) sewage water that does not contain significant poisonous industrial pollutants is a suitable medium for fish culture. Fish culture associated with duck, chicken, and pig rearing as the source of fertilization is common in countries throughout the world, and is an effective solution to domestic animal waste management problems. This is mainly an Asian fish culture practice, but is also a long practiced method in Europe (Bardach et. al., 1970; Woynarovich, 1976) and Israel (Schroeder and Hepher, 1976); and is used on experimental bases in the United States (Buck et.al., 1976). Odum (1974) also sites a study in Israel; fish ponds serve as nutrient traps where most of the organic compounds are either precipitated, lost to the atmosphere, bound by the sediments, or tied up in fish flesh so that a minimum amount of nutrients leaves the ponds. The amount of sewage that can be put through a pond is determined by maintaining the BOD level at a safe point to prevent oxygen depletion. Daily rates of sewage addition can be inexcess of 1.5 tons/ha. These sources of nutrients serve to enhance primary prodution along with a fauna associated with eutrophic conditions. The mineralized portion of the manure provides nutrients to the phytoplankton while the non-mineralized portion serves as a food base for zooplankton. This food source is in turn utilized by the stocked fish population (usually _Tilapia_ or carp). Utilization of carp in the treatment of nutrient-enriched waste waters is practiced in Indonesia and Germany (Bardach et.al., 1970). The carp feed on the natural productivity of the waters. Recent studies (Carpenter, 1974; Coleman et.al., 1974; Goldschmidt, 1970; Schroeder, 1975) have indicated that fish improve the waste treatment capacity of pond systems. Utilization of fish ponds for this purpose on Guam is feasible. They also have been used in effluent wastes from dairies, sugar mills, slaughterhouses, and starch mills. Part of pond ecology and proper management is the use of species to utilize excess food thus affecting reduction of pollution, improvement of pond environment, and greater production. Yields of fish grown in such ponds, with no supplemental feeding, have been as high as 4000 kg/ha/year (Schuster et.al., 1954; Schroeder and Hepher, 1976).

Public Health

Fish may serve as a passive carrier of infectious human diseases such as Salmonella, Vibrio parahemolyticus, Shigella, or other enterobacteria (Janssen, 1970; Guelin, 1962; Buttiaux, 1962). The occurence of these diseases from fish caught in polluted waters was noted by Shewan (1962). However, the pathogens are confined to infecting the gut of fish (Allen, Busch, and Morton, 1976), so that with proper precaution in preparation of the fish this possible hazard could be eliminated. There is danger of introducing Schistosomiasis as had happened in the Caribbean (Odum, 1974). With rapid air transport of live aquatic species from tropical areas the survival chances of waterborne stages of flukes and other pathogens has increased (Courtney and Robins, 1975). The limited knowledge in this area (Sonstegard, 1975)will require further research as aquaculture expands.

Exotic Species

The introduction of exotic species for the purpose of aquaculture is often a necessity in establishing a viable aquaculture industry; however, candidate species for introduction should be carefully examined in regards to their ecology, behavior, reproduction, and marketability. Indescriminate introduction can lead to the detriment of the endemic species and possibly their elimination in addition to threats to established culture species (Allen, 1949; Frankenberg, 1966; Lanchner et.al., 1970; Buckow, 1969;

Idyll, 1969).

Some detrimental effects that may result from the introduction of exotic species are; reduced growth of introduced species due to less favorable environmental conditions than those found in their indigenous area, a population explosion of the introduced species leading to competion with, and possible elimination of native species, introduction of new pests, diseases, and parasites harmful to resident species, and destructive activitities of the introduced species affecting other fields of economic interest (e.g., common carp in the U.S.) (Rosenthal, 1976).

ROLE OF AQUATIC AND WILDLIFE RESOURCES

The Division of Aquatic and Wildlife Resources should continue to play an instrumental part of the development and support of an aquaculture industry on Guam. Aquatic and Wildlife Resources initiated investigation into the prospects of aquaculture on Guam in 1973. The initial phase of the program dealt with the investigation into feasible species for culture on Guam with experimental-demonstration ponds located on the Talofofo River. The second phase consisted of assisting in the establishment of commercial ponds with extension service provided to the entrepreneur. This is continued into the present program with the addition of the pursuit in establishment of a hatchery on Guam, so that Guam can become self-sufficient in production of the major cultured species juveniles.

All importation of live fish (including crustaceans and turtles) requires a permit which is issued by Aquatic and Wildlife Resources. Shipment of species from foreign countries (outside U.S. and T.T) requires, in addition to the Aquatic and Wildlife Resources permit, a permit issued by the Federal Fish and Wildlife Service for some species. This system is intended to screen out the introduction of undesireable species and species originating from countries that have a high disease occurence or the presence of a disease that does not occur on Guam that might be carried by the introduced species. This also can restrict importation of species that might be detrimental to established aquaculture species.

The introduction of a large number of exotic species to Guam would be ill-advised; however, the major species that will be most suitable for aquaculture will be exotic to Guam. The utilization of species which have proven their success as a culturable species should have priority for examination of their potential on Guam. This usually involves an extensive degree of technical and practical knowledge available on a species culture and careful selection weighing all the pro and con arguments both concerning its economic and biological impact. This regulatory and research function will have to be mainly fullfilled by the Aquatic and Wildlife Resources Division. However, an interagency screening committee consisting of the Guam Environmental Protection Agency, University of Guam Marine Laboratory, and Aquatic and Wildlife Resources, should be formed to review all new introductions.

For the aid in inforcement of an affective environmental protection program the Aquatic and Wildlife Resources should keep the Guam Environmental Protection Agency aware of scheduled large discharges (e.g., during harvest). This allows for the proper monitoring of effluents. In addition, Aquatic and Wildlife Resources should oversee application of toxic substances to fish ponds for the purpose of elimination of pest species. Potential farmers should be advised of requirements and permits required from other agencies. The construction of the aquaculture facilities should be observed by Aquatic and Wildlife Resources along with other appropriate governmental agencies to assure that excessive abuse of the environment does not occur.

Aquatic and Wildlife Resources in conjunction with the Public Health Department, should screen all imported aquatic species coming from areas that infectious diseases can be carried by fish (fish or human pathogens). This could consist of impounding in concrete tanks and treating with proper prophylatic drugs. Specimens that are obviously diseased should be destroyed.

If local facilities were available for the propagation of these preferred culture species then this would eliminate the need for importation and its possible accompanying health problems.

CONCLUSION

Guam has the climatic and physical conditions for the development of a diverse and productive aquaculture industry. This potential, needs to be recognized by both governmental agencies and private entrepreneurs, so that proper and well-planned development can proceed.

A state program should be drawn up to cover the development of aquaculture and its supportive facilities (laws, policies, and administrative procedures) to encourage its development. In addition, the over-seeing of environmental protection measures should be realistically enforced to prevent abusive use of Guam's waters. Decisive effort is needed to put into operation a viable aquaculture program that is consolidated into a workable industry that will attract the businessman/farmer into this new industry on Guam.

The governmental agencies involved in this formation of a state program should be limited to those directly concerned with the functional operation of an aquaculture industry, thus preventing an over diversification of authority, which would hinder development.

ACKNOWLEDGEMENTS

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Soil Types (Tracey et.a ., 1959)

2 - Toto Clay: Brown to pale-yellow, firm plastic, slowly permeable, acid clay with reddish stains (Grumusol); ranges 5 to 30 feet in depth and averages 10 to 20 feet; has very high shrinkage and expansion (large cracks in dry season; depressions ponded in wet season); prevailing surface gradient 1 to 8 percent.

3 - Chacha-Saipan Clays: Yellowish-brown, firm clay (Chacha), and red, firm clay (Saipan); neutral to acid reaction; Latosolic intergrades. These soils with concave survaces they are 10 to 60 feet deep; prevailing surface gradient 1 to 8 percent.

6 - Atate-Agat Clay: Remnant benches or small mesas of an old red, granular, porous, acid Latosol (Atate clay) with deep, reddish, mottled, plastic to too hard clay C horizon, pale yellow, olive, or gray in lower part; and its truncated counterpart (Agat clay) with similar C horizon of saprolitic clay, ranging in depth from a few feet to about 100 feet and averaging about 50 feet; prevailing surface gradient of Atate clay is 1 to 8 percent, and of Agat clay 8 to 15 percent.

9 - Pago Clay: Brownish, granular to firm and plastic Alluvial clay, with gray mottling to within 24 to 30 inches of the surface; generally alkaline to neutral; soil depth is generally more than 10 and less than 150 feet; moderately well drained; subject to occasional flooding; prevailing surface gradient 1 to 3 percent.

10 - Inarajan Clay: Similar to Pago clay but lower, wetter, and shallower (thins out on coastal sands and bedrock); water table at or near the surface (within 30 inches) most of the time; poor drainage mottlings (gray) within 6 to 12 inches of the surface; depth to sand or bedrock ranges from 3 to 25 or more feet; reaction is alkaline in water saturated zone; poorly drained; frequently flooded; prevailing surface gradient 0 to 1 percent.

11 - Muck: Black to brown, soft muck and peat, with some clay and silt; depth to underlying material (chiefly limesand or shelly clay) ranges from 3 to 20 feet, averages 5 to 10 feet; alkaline reaction below the water table, which is generally at or near the surface; prevailing surface gradient is level or very nearly level.

THE EXENT OF CORAL, SHELL, AND ALGAL HARVESTING IN GUAM WATERS

Steven E. Hedlund

Prepared For

Coastal Management Section
Bureau of Planning
Agana, Guam

University of Guam Marine Laboratory

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INTRODUCTION

The single most important natural resource of a tropical Pacific island is its coral reef, for without the reef there would be no island. The coral reef acts as a barrier to reduce the force of wave action upon the land. In addition, the reef provides a natural habitat for a variety of plant and animal life which integrate with the environment to form the most complex ecosystem in our world today. The people of Guam utilize the reef for recreational purposes as well as a source of food. Because of its beauty, economic and scientific value, along with the fact that it is potentially exploitable, the coral reef has been designated as an area of particular concern on Guam.

Ten years ago scientists felt that coral reefs were so very fragile that man should not even think about harvesting the very substance from which they are composed. Today this attitude has changed and reef organisms are regarded as harvestable and renewable resources. However, these resources are potentially limited and therefore great care must be taken to conserve them and regulate their harvest.

In recent years, more and more people have begun collecting corals, shells, and algae for their ornamental beauty and food, and commercial harvesting has also increased greatly. In order to assess the extent and effect of harvesting these organisms from Guam waters, the Coastal Zone Management Section of the Bureau of Planning contracted the University of Guam Marine Laboratory (Graduate Student Steven E. Hedlund) to undertake such a study.

Scope of Work

The specific objectives of this analyses are as follows:

(1) To determine which species of corals, shells, and algae are being harvested and to what degree.

(2) To determine where the majority of harvesting is being done, and provide maps based on such data.

(3) To review and provide information on existing laws and their enforcement.

(4) To make recommendations regarding protection of certain species, stricter law enforcement, or change in existing laws.

METHODS

This study was divided into four sections, with the main emphasis being on the first section dealing with coral. The second section analyses shells, followed by the third section which covers the algae. The fourth and final section concerns existing laws and their enforcement.

In order to ascertain which species of corals, shells and algae are being harvested and to what degree, along with harvest locations, a number of personal interviews were conducted with the owners, managers, and sales clerks of stores that were found to be selling these natural products.

In the case of corals, these interviews yielded information regarding species, prices and amounts marketed, and in some instances led to the source of supply. However, information was not freely given in certain cases and therefore information pertaining to harvesting locations is not that extensive.

It was found that only one store actually markets local shells to a very small degree, and an interview was conducted with the owner. Since local shells are not harvested regularly on a commercial level, a series of interviews were conducted with knowledgable sources. These included amateur and professional conchologists, along with Andersen Air Force Base Shell Club members and various divers.

Currently, local edible algae are not marketed on a regular commercial basis. Therefore, what little data was gathered came mostly from a study being conducted by Dr. Roy Tsuda and the author regarding the mariculture potential of the red alga *Gracilaria edulis*. Additional information was obtained from brief interviews with local fisherman who sometimes gather edible seaweed.

Finally, in an effort to analyze and review existing legislation and enforcement of laws regarding coral, shell, and algae harvesting in Guam waters, interviews were conducted with Mr. Harry Kami, Chief of the Aquatic and Wildlife Resources Division-Department of Agriculture.

RESULTS AND DISCUSSION

Corals

The natural beauty of dried and mounted coral make it a much desired ornamental product of nature. Some species cut and polish nicely and are thus in great demand by local jewelers. These are the two main reasons why corals are harvested from Guam waters, for ornamental use and jewelry work.

Information regarding the species, amounts, dates and sources of supply of locally marketed coral is presented in Table 1. From this data, estimates of the monetary value of annual commercial consumption were derived and can be found in Table 2.

An analysis of the data presented in Table 2 reveals that over the last two and one-half years the commercial market for locally harvested coral has been subject to fluctuation. In fiscal year 1975 a total of $9,550 was sold as compared with $8,425 sold in 1976. This is primarily due to an unreliable supply rather than a fluctuating demand. The increase to $12,225 sold thus far in 1977 is due to the establishment of the Elmar Corporation L.T.D., which deals with expensive coral jewelry made from fossil and subfossil specimens.

Further analysis of the data from Table 2 showed that the most common species of coral which are harvested on a commercial level from Guam waters are, in order of importance (most exploited).

(1) Acropora irregularis
(2) Acropora spp. (fossil and subfossil origin)
(3) Acropora acuminata
(4) Antipathes dichotoma
(5) Fungia fungites
(6) Heliopora coerulea*
(7) Tubipora musica*

In an attempt to determine the locations of local harvesting activities, a number of interviews were conducted with the "sources" listed in Table 1.

Dr. Blair Sparks, the owner of Shells of Micronesia, was interviewed three different times, with each interview lasting no more than ten minutes. Although Dr. Sparks did not wish to discuss his business volume or harvesting location, some information was gathered regarding the latter through outside sources. Dr. Sparks son, Sam, is in charge of the collecting and his harvesting method involves breaking off huge coral heads at the base with a heavy iron bar. Figure 1 shows the main harvesting location and depth.

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*At this time it is impossible to determine the extent that these two species are exploited due to the fact that information was not freely provided by the owner of the store where these species are sold. (See Table 1)

Table 1. Species, amounts, dates and sources of supply of locally marketed coral.

Store	Species	Amount ($)	Date	Source
Orient Co. (Julale)	*Acropora acuminata*	$50-100/month	Jan.'75-May'76	Unknown Student
Blue Pacific Gift Shop (Fujita)	*Acropora* sp.	$50/month	Jan.'75-Dec.'75	Unknown Naval Seaman
Continental Gift Shop	*Acropora irregularis*	$50/month	Jan.'75-Jan.'76	World Shells (Dr. Blair Sparks)
Shells of Micronesia	*Acropora irregularis* *Heliopora coerulea* *Tubipora musica*	* * *	* * *	Dr. Blair Sparks (Owner) Mr. Sam Sparks
Elmar Corp. L.T.D. (I.T.C. Building) w/ outlets at Hilton, Gibsons, Int. Gift Ctr., Jennys Fashion, Joelle, Okadaya	*Acropora* spp. (fossil and sub-fossil origin)	$2000/month	Jan.'77-June'77	Mr. Choi (Owner)
Gold Guild Custom Jewelry (Julale)	*Antipathes dichotoma*	$25-50/month	Jan.'75-June'77	Mr. Mack
Tritons Treasures Jewelry	*Antipathes dichotoma*	$25-50/month	Jan.'75-June'77	Mr. Mack
Duty Free Shoppers	*Acropora irregularis* *Fungia fungites*	$600/month $40/month	Jan.'75-Dec.'76 Jan.'75-Dec.'76	World Shells (Dr. Blair Sparks)

*Information was not freely provided by owner.

Table 2. Estimates of the monetary value of annual commercial consumption of the most commonly harvested corals from Guam waters.

Species Harvested	1975	1976	1977	TOTAL
Acropora acuminata	$ 900	$ 375	--	$ 1,275
Acropora spp. (fossil and subfossil origin)	--	--	$12,000	$12,000
Acropora irregularis	$7,200	$7,200	--	$14,400
Acropora spp.	$ 600	--	--	$ 600
Antipathes dichotoma	$ 450	$ 450	$ 225	$ 1,125
Fungia fungites	$ 400	$ 400	--	$ 800
TOTAL	$9,550	$8,425	$12,225	$30,200

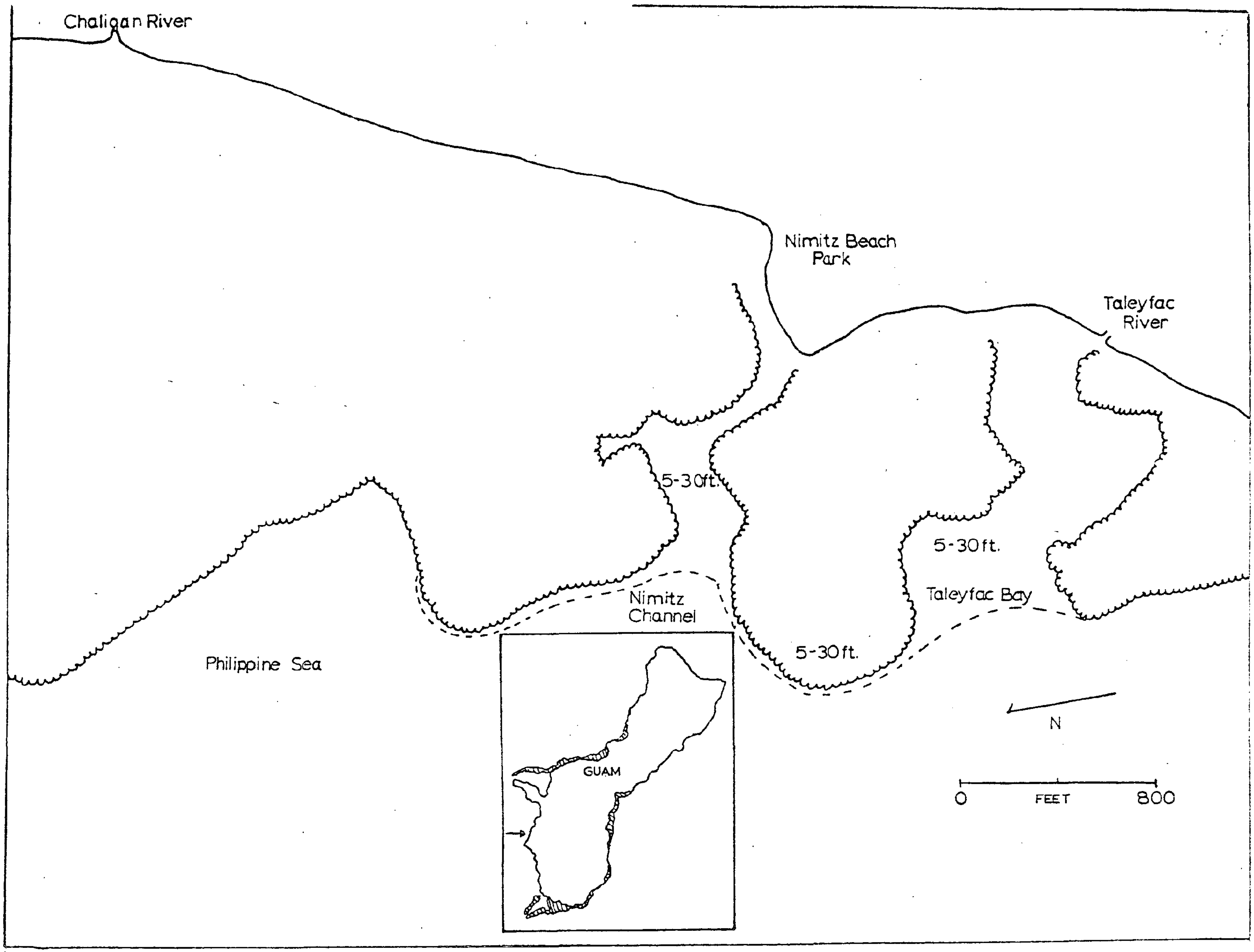

Figure 1. Location (indicated by dashed line) and depth at which *Acropora irregularis* is harvested.

The founder and owner of Elmar Corp. L.T.D. (Natural Flower Coral) was interviewed twice for periods of one-half-hour. Mr. Choi stated that he harvested a number of times all around the northern tip of Guam. This is rather general data and I therefore refer you to maps #77-89 in the Atlas of Reefs and Beaches of Guam. Mr. Choi's method of harvest involved a specially equipped boat with deep sea dredge. He stated that he dredged at depths between 100-1000 ft. The main species harvested were Acropora spp. of fossil and subfossil origin.

The only man working with the precious black coral on Guam is Mr. Mack, a science teacher at G.W.H.S. However, he only cuts and polishes, and does not actually collect the black coral Antipathes dichotoma. Mr. Mack obtains his coral from a couple of divers who wished not to be named. Their method of harvest involves sawing off large fans at the base. Figure 2 shows the main harvesting location and depth.

Shells

The natural beauty of marine shells makes them a prime target for the collector's eye. The main reason shells are gathered from Guam's reef is for display in private collections. A very minute quantity is sold in the curio shop Shells of Micronesia, and some species are cut, polished and made into jewelry by local artists. Various species of marine gastropods and numerous bivalves are gathered and eaten by the local population.

In recent years the number of shells to be seen on Guam's reef has been greatly reduced. In order to determine the most common species gathered along with amounts and locations of harvest, a number of interviews were conducted which yielded the following information.

From an interview with Mrs. Cheryl Richardson, a conchologist who has resided on Guam since 1973, and various members of the Andersen Air Force Base Shell Club, data were obtained regarding the most common species gathered islandwide along with their habitat preference. This information is presented in Table 3.

An interview conducted with Mrs. Richardson and Sergeant Jim Rogers, another very capable conchologist, yield information regarding the most commonly shelled areas of Guam along with the most sought after species found in these areas. This data is presented in Table 4, and locations are indicated on a Guam map at 1:25,000 scale.

Sergeant Rogers has been collecting shells for over twenty years and lived on Guam from February 1961 until November 1962, at which time he was actively collecting. He returned to Guam in October of 1972 and

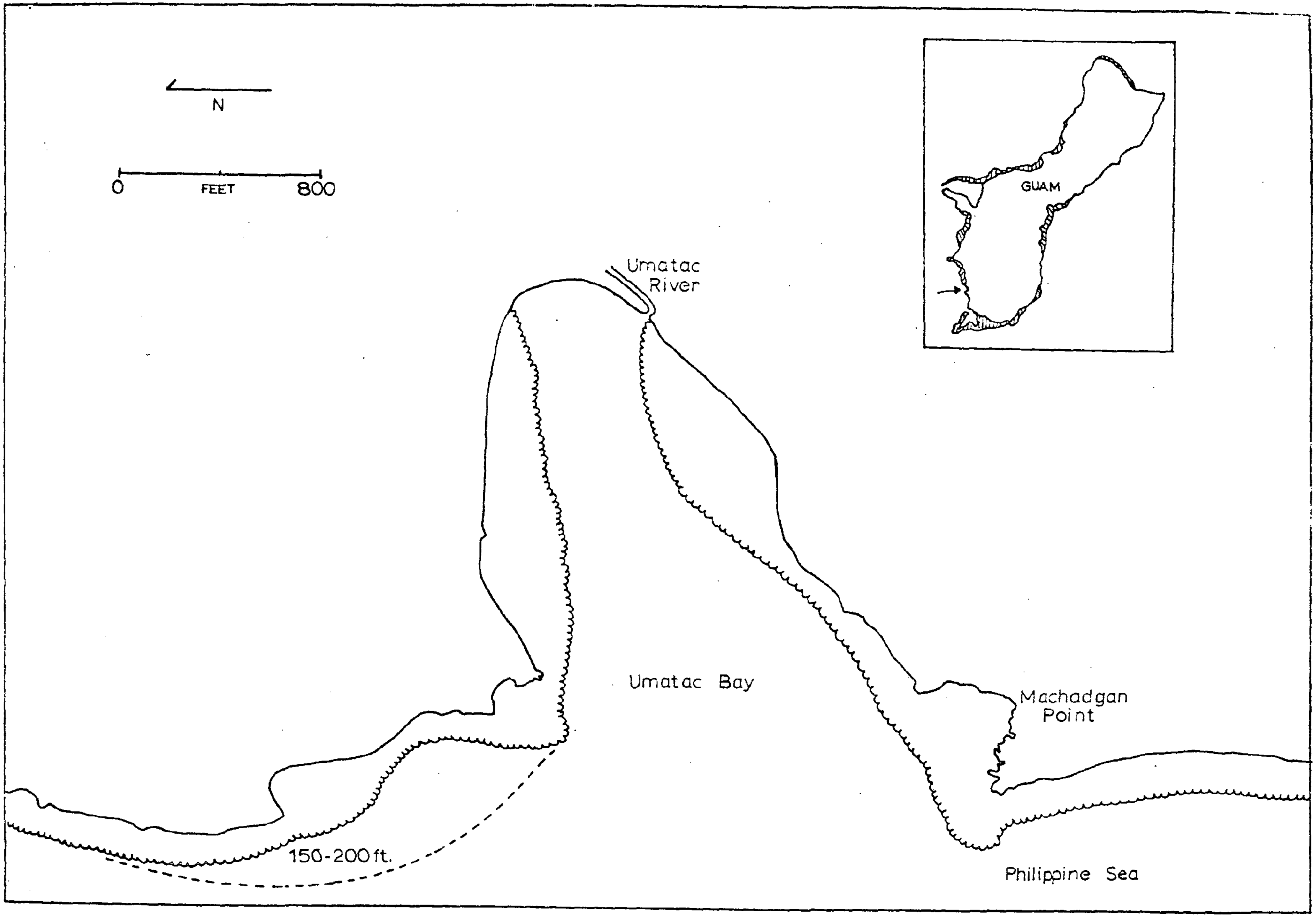

Figure 2. Location (indicated by dashed line) and depth at which Antipathes dichotoma is harvested.

Table 3. Checklist of the most common species of marine gastropods gathered islandwide from Guam waters, along with their habitat preference.

SPECIES	HABITAT
Conus eburneus	Sand
Conus pulicarus	Sand
Cypraea annulus	Under Rocks
Cypraea caputserpentis	Reef Margin, Front
Cypraea erosa	Sand, Coral Rubble
Cypraea moneta	Sand, Coral Rubble
Cypraea ventriculus	Reef Margin
Drupa morum	Intertidal, Reef Margin, Front
Drupa ricinus	Intertidal, Reef Margin, Front
Lambis lambis	Sand
Strombus luhuanus	Intertidal
Strombus mutablis	Intertidal
Terebra affinis	Sand
Terebra dimidiata	Sand
Terebra maculata	Sand

Table 4. The most commonly shelled areas of Guam, along with the most sought after species found therein.

LOCATION	SPECIES
Scout Beach (E. of Tarague)	Conus ebraeus Thais aculeata Trochus incrassatus Trochus niloticus
Tarague Beach	Cypraea maculifera
N.C.S. Beach	Conus textile Cypraea maculifera
Tumon Bay	Cypraea lynx
Adelup Point	Conus textile Conus tigrinus
Asan	Conus imperialis Cypraea ventriculus Lambis truncata
Piti - U.S.O. Beach	Cypraea poraria Cypraea talpa Mitra spp. Terebra babylonia
Apra Harbor (Hotel Warf, Pine Tree Cove, Jade Shoals, Western and Middle Shoals, Gab Gab Beach)	Cypraea mauritiana Cypraea tigris
North and South Tipalao	Cypraea lynx Cypraea mauritiana Cypraea tigris Cypraea vitellus
Rizal Beach	Mitra terebralis
Agat Beach	Cypraea testudinaria
Nimitz Beach-Anae Island	Conus quercina
Cocos Lagoon	Cypraea tigris Conus leopardus Conus litteratus Lambis truncata

thus was able to provide some interesting information regarding the change in shelling conditions over the last fifteen years.

Sergeant Rogers stated that both Tumon and Agana Bays were fantastic shelling areas in the early sixties. He attributed the drastically reduced gastropod populations not only to increased shelling, but more importantly to increased pollution in the last five years, especially in Agana Bay. The Cocos Lagoon area was also very rich in shell life many years ago and has been depleted mainly due to increased shelling. Sergeant Rogers stated that the helmet shell Cassius cornuta was very abundant in the Cocos area when he first came to Guam, and that only one specimen has been reported since his return in 1972. Another gastropod whose population size has been severely decimated over the years is the triton trumpet, Charonia tritonis. This animal is a natural predator of the coral eating crown-of-thorns starfish, Acanthaster planci, and thus has been speculated to be an important factor in controlling its population size.

Three additional marine gastropods which are considered very rare include:

(1) Oliva miniacea (form marrotti)
(2) Strombus aurisdianae
(3) Strombus bulla

Sergeant Rogers feels that the best way to help increase the population of shells in Guam waters is to educate the people. Ignorant shellers cause a great deal of irreparable damage by leaving rocks overturned and taking females with eggs. The public should therefore be made aware of the basic rules of shell collecting, i.e.,

(1) Do not take females with eggs.
(2) Do not leave rocks overturned.
(3) Take only one of each species.
(4) Try to gather large adults rather than immature juveniles.
(5) Try to gather dead shells rather than live ones.

These facts could be publicized through short radio broadcasts, newspaper articles, and signs posted at public beaches in both English and Japanese. In addition, new swimmers and divers should be made aware of these rules through their courses. In this way marine gastropods will have a better chance to reach reproductive maturity and increase their population size.

An interview with Dr. Blair Sparks, owner of the curio shop Shells of Micronesia, revealed that approximately $100 in local shells are sold each month. These include a wide variety and information regarding species and amounts marketed along with location harvested was not available.

Shells of Micronesia also sells earings and pendants fashioned from the shell of Strombus luhuanus, a very common marine gastropod. The store Tritons Treasures also markets this jewelry created by local craftsmen. Creative art work from common shells should be encouraged.

Various species of marine gastropods are known to be harvested as a food source. Two of the most commonly exploited species are Turbo argyrostoma which is found on the reef bench and Trochus niloticus found on the reef front and in intertidal areas.

Four species of marine bivalve were found to be harvested by local people as a food source. These include Codakia tigerina, Periglypta puerpera, Quidripagus palatam, and Tridacna maxima.

All of these bivalves are found islandwide in sandy intertidal areas with the exception of Tridacna maxima which is found on the reef front.

Algae

Probably the most important components of the coral reef ecosystem are the phytoplankton and algae, for without these the reef could not exist. These micro and macroscopic plants are the primary producers and thus provide food and energy for the multitude of other organisms inhabiting the reef. Besides being a source of food to many creatures which inhabit the reef, some species of macroalgae are eaten by man.

In an effort to determine which species of algae are harvested from Guam waters, along with amounts and locations of harvest, interviews were conducted with knowledgeable sources, i.e., fishermen and store owners.

A survey of island grocery stores and small markets revealed that currently no local algae is marketed on a regular basis. However, it was discovered that the green alga Caulerpa racemosa is sometimes sold at the Saturday morning flea market for 25¢ a pound. This alga, commonly known to Guamanians as "ado", is one of two marine algae eaten by local people. (Codium spp. was also marketed at the Flea market for 25¢ a pound, but only Filipinos eat this alga). The other seaweed that is harvested for food is the red alga Gracilaria edulis, better known as "chaguan tasi." This alga is currently being studied by Dr. Roy Tsuda and the author at the University of Guam Marine Laboratory, in relation to its possible mariculture potential. Although the local people on Guam are not heavy seaweed consumers, preliminary tests on the marketing of Gracilaria edulis were encouraging.

At the present time only two reef areas are known to be regularly harvested for algae. In Pago Bay the green alga Caulerpa racemosa is gathered and in Sella Bay Gracilaria edulis is harvested. These locations are depicted in Figures 3 and 4.

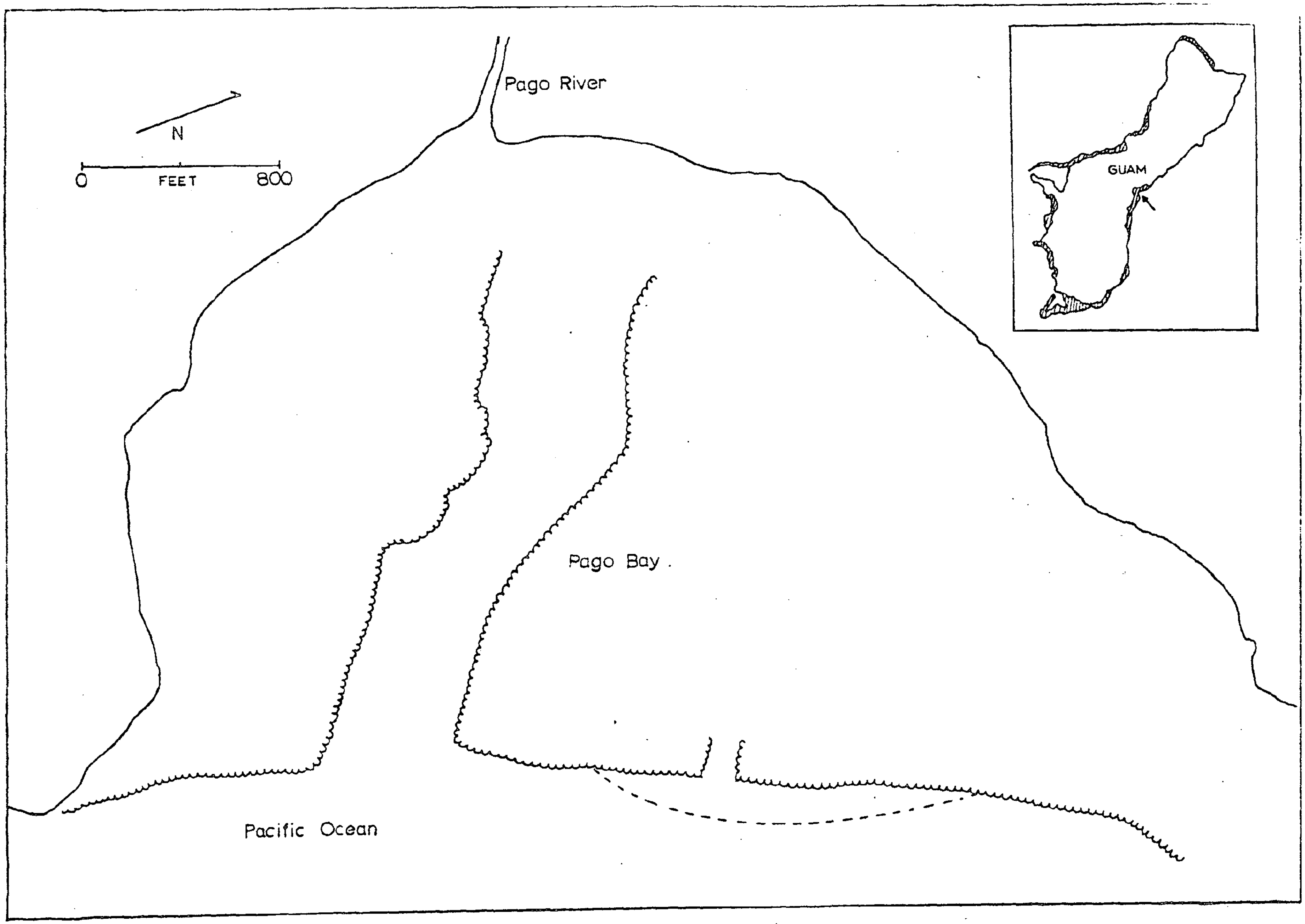

Figure 3. Location (indicated by dashed line) where the green alga Caulerpa racemosa is harvested.

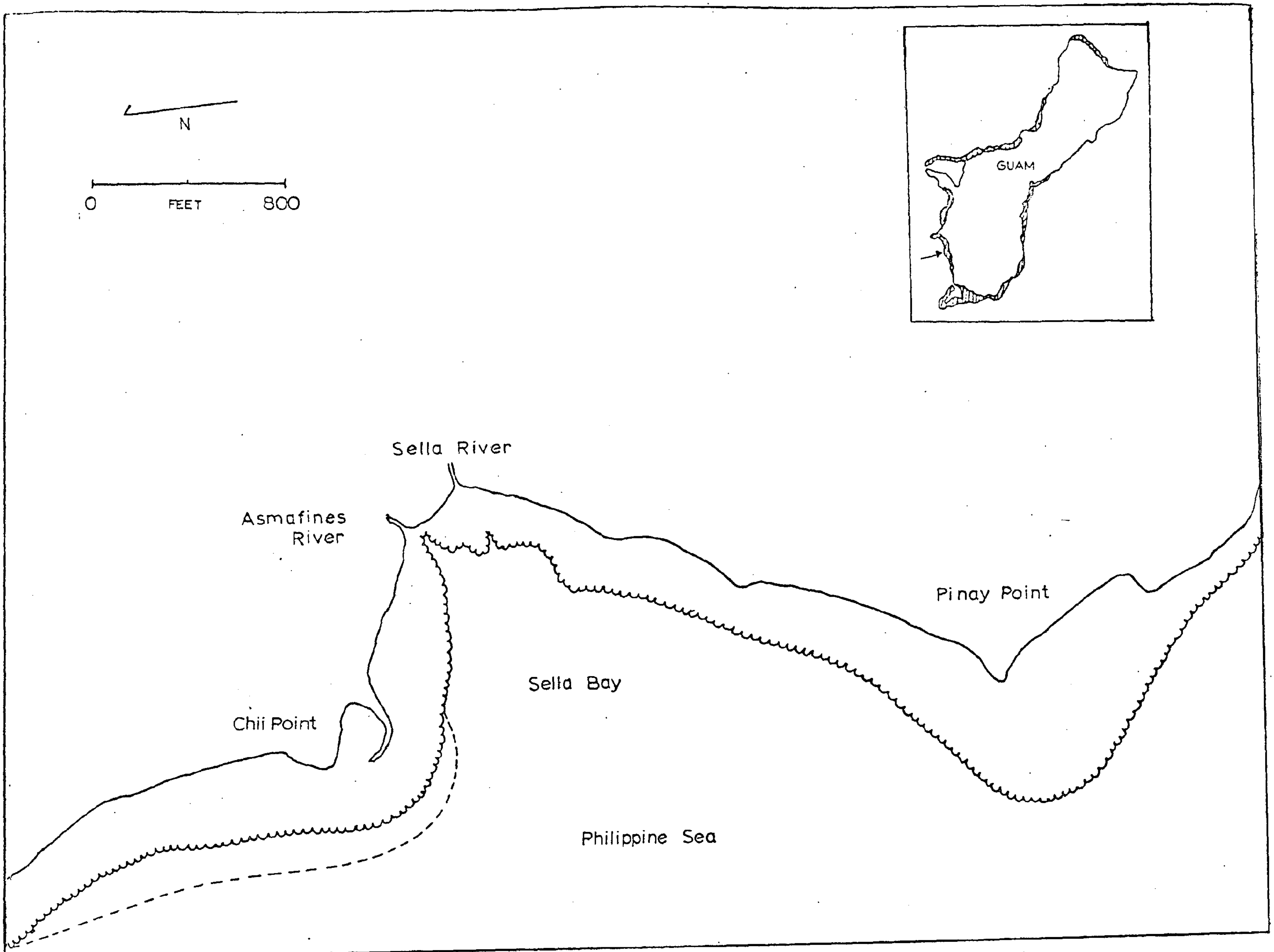

Figure 4. Location (indicated by dashed line) where the red alga *Gracilaria edulis* is gathered.

Legislation

In order to analyze and review existing legislation and enforcement of laws regarding coral, shell and algal harvesting in Guam waters, interviews were conducted with Mr. Harry Kami, Chief of the Aquatic and Wildlife Resources Division of the Department of Agriculture.

Corals

It was found that on October 30, 1974, during the second regular session of the Twelfth Guam Legislature, Bill No. 416 (introduced by F. G. Lujan), was duly and regularly passed. The creation of Public Law 12-186 was "An Act adding a new Article 4 to Chapter 4 of Title XIII, Government Code of Guam to regulate the taking of live coral, and for other purposes." A copy of Public Law 12-186 is appended. It is divided into five sections:

Section 12380 states, "It shall be unlawful to remove live coral from that area surrounding the Island of Guam extending from shore outwards to the ten fathon contour, except in accordance with this Article."

Section 12381 deals with the harvesting of coral, both commercially and for other purposes.

Section 12382 deals with the nature of commercial permits.

Section 12383 states the penalties for any violation of this law.

Section 12384 deals with the enforcement of this law.

In accordance with Section 12381 Part A, regarding the commercial harvesting of coral, no permits had been issued as of May 27, 1977.

In accordance with Section 12381 Part B, regarding the harvesting of coral for purposes other than commercial sale, only three permits had been issued as of June 28, 1977. These include the following:

(1) Environmental Protection Agency

Issued December 9, 1975 - Expired June 30, 1976
Purpose: For reference collection.

(2) Aquatic Environments (Agat)

Issued June 12, 1975 - Expired June 13, 1975
Purpose: For aquarium use.

Issued February 24, 1977 - Expired March 4, 1977
Purpose: For aquarium use.

(3) Marine Laboratory (University of Guam)

Issued May 18, 1977 - Expired June 19, 1978
Purpose: Biological reference and research.

Over the last few years many hermatypic corals have been illegally harvested from Guam waters for commercial use. However, it is believed that a much larger quantity has been harvested illegally for purposes other than commercial sale. This includes individuals who gather for private collections and gifts, along with tourists who want a "souvenir" from Guam. Also, Acropora spp. are sometimes gathered to make "lime" for betelnut.

Interviews with coral gatherers and sellers revealed that few were aware of or concerned about existing laws relative to their activity. Clearly, a public information program is needed, especially if future regulations are to be respected. This could be accomplished through short radio broadcasts, newspaper articles and signs posted at public beaches in both English and Japanese.

The existing Public Law 12-186 which prohibits the taking of live coral above the depth of ten fathoms, is essentially a good law, however, it has been found to be unenforceable. (As of May 27, 1977 no arrests had been made). Mr. Harry Kami believes that the law would be more effective if it were amended to prohibit the taking of live coral at any depth rather than to just ten fathoms. This would require all persons wishing to collect live coral for any reason to apply for a permit or license. In this way all doubt regarding a harvesters legality would be alleviated.

In addition, given the present lack of enforcement personnel at the Division of Aquatic and Wildlife Resources, thought should be given to developing guidelines that could be exercised at the sales level, for example a third copy of the receipt might be required for all sales and presented to the Division of Aquatic and Wildlife Resources, thus indicating the seller.

Mr. Dick Randall, the coral specialist from the University of Guam Marine Laboratory, believes that only three species of coral are rare enough to warrent total protection. These include Euphyllia spp., Plerogyra sinuosa, and Tubastraea aurea.

Mr. Randall also feels that certain areas should be set aside as underwater reserves with complete protection. One such area is in the vicinity of Aneae Island, which is one of the fastest developing sections of reef around Guam. Other reserve areas might correspond with the Pristine Marine Environment study currently being conducted by the Coastal Zone Management Section of the Bureau of Planning.

In addition, certain areas of reef might be determined where controlled harvesting of live coral could be undertaken and monitored on a continuing basis. The establishment of reserve areas and harvestable areas of reef are both possible through Section 12382 Part B of the existing Public Law 12-186.

At this point in time the amount of live coral being harvested from Guam waters is not that great. An estimated 2,000 pounds of hermatypic and precious corals are harvested annually. When compared to the biomass of even a small area of reef this amount is very negligible. The harvesting of dead corals of fossil and subfossil origin has no adverse effect on the reef and should be encouraged.

The hermatypic coral that is presently being exploited to the greatest extent is *Acropora* spp. This is also one of the most abundant corals in Guam waters and therefore commercial and private permits can be issued more freely to harvest these species. On the other hand the harvesting of the hermatypic corals *Heliopora coerulea* and *Tubipora musica* along with the precious black coral *Antipathes dichotoma* should be more restricted. There should be no restriction for harvesting corals of fossil and subfossil origin.

In order to more precisely determine the environmental impact of harvesting live corals, studies analyzing distribution patterns, growth rates, and abundance of the most commonly harvested species should be made. Some of these studies are presently being conducted by the faculty of the University of Guam Marine Laboratory. If the coral industry continues to expand in future years, certain stringent controls may be necessary to avoid overexploitation of this resource.

Shells

The only existing legislation regarding marine gastropods concerns the commercial harvesting of trochus shells. According to the Government of Guam Department of Agriculture regulation No. 28, the commercial harvesting of *Trochus niloticus*, is limited by size, season, area and requires a license. A copy of regulation No. 28 is contained herein. As of June 28, 1977 no arrests had been made and no one had applied for a license.

Algae

At the present time no legislation exists regarding the harvesting of marine algae. It is very doubtful that such legislation would need to be enacted in the near future. In fact people should be encouraged to gather the edible seaweeds as a natural and cheap additional protein and mineral supply to their diet.

RECOMMENDATIONS

It is hoped that the following recommendations regarding coral, shell and algal harvesting in Guam waters will be an aid to future management of these resources.

Coral

1. Amendment of Public Law 12-186 Section 12380 to read, "It shall be unlawful to remove live coral from Guam's reef, except in accordance with this article."

2. In accordance with Section 12382 Part B;

    a) Protection of the following species; *Euphyllia* spp., *Plerogyra sinuosa*, *Tubastraea aurea*.

    b) Establishment of underwater reserves.

    c) Establishment of reef areas where controlled harvesting could be undertaken and monitored on a continuing basis.

3. Requirement that all buyers furnish a third copy of receipts for all purchases to the Division of Aquatic and Wildlife Resources, indicating the identity of the person selling.

4. Public information program to educate coral harvesters and sellers of existing laws should be developed.

5. Study involving the analysis of distribution patterns, growth rates, and abundance of the most commonly harvested species should be intensified.

Shells

1. Legislation should be enacted to protect the following species, *Cassius cornuta* and *Charonia tritonis*.

2. Public information program to educate shell gatherers about the basic rules of shelling should be developed.

Algae

1. Brief public information program to make people aware of the nutritional value of edible algae.

ACKNOWLEDGEMENTS

I am especially grateful to Dr. Roy T. Tsuda who arranged for me to conduct this study, and reviewed the manuscript. His suggestions and criticisms along the way were very much appreciated.

Many thanks go to Richard Randall who identified coral specimens, reviewed the manuscript and gave many helpful suggestions. Dr. Lu Eldredge provided very useful literature and offered constructive suggestions. Mike Gawel, as project coordinator, kept me in line and provided many stimulating suggestions. Russell Clayshulte and Richard Dickinson provided useful information regarding harvesting locations and shells respectively.

Thanks to Mr. Harry Kami for providing a copy of existing legislation and offering very useful suggestions. Also, thanks go to Mr. Mack, Mr. Choi, Dr. Blair Sparks and many, many others who patiently answered my questions.

Thank you Mrs. Terry Balajadia for typing the entire manuscript.

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ARTICLE V

Live Coral and Fishing Nets

§ **12380. Taking of live coral: unlawful.** It shall be unlawful to remove live coral from that area surrounding the Island of Guam extending from the shore of the island outwards to the ten fathom contour, except in accordance with this Article.

12381. Harvesting of coral. (a) The commercial harvesting of coral may be conducted by obtaining a license from the Director of Agriculture and the payment of a fee as established by the Director.

(b) For purposes other than the sale of coral, live coral may be taken only by obtaining a license from the Director of Agriculture, such license being limited in time to a maximum of five (5) days at any given time and to a specific location from which the coral is to be taken, and for such license a fee may be charged. The Director may restrict the amount of coral to be taken under any license and may impose such other restrictions as may be necessary to insure the conservation of our coral fields.

§ **12382. Commercial permits.** (a) Permits for the Commercial taking of coral may be issued by the Director of Agriculture upon the following conditions:

1. The permit must state the individual or individuals who will be taking the coral;
2. The permit must state the time, date and location from which the coral is to be taken;
3. The Director may limit each permit to a specified amount of coral to be taken, taking into account the location from which the coral is to be taken, the amount of living coral remaining and the likelihood of damage caused to the reef area by the taking of the coral.

(b) The Director of Agriculture may, by regulation, establish a fee schedule based upon the amount of value of the coral to be taken commercially; establish areas on Guam where no coral may be taken, limited coral may be taken or unlimited coral may be taken, and impose any other restrictions necessary for the conservation of our coral reserves, all subject to the permits as required by this Article.

§ **12383. Penalties.** Any violation of this Article or the regulations and permits issued pursuant to it shall be a misdemeanor punishable by a fine of not more than Five Hundred Dollars ($500.00) or by imprisonment of not more than six (6) months or by both such fine and imprisonment for each offense.

§ **12384. Enforcement.** This Act shall be enforced primarily by the Director of Agriculture and the Conservation Officers as authorized by § 12302 of this Title and secondarily by Peace Officers defined in § 851 of the Penal Code of Guam. [§§ 12380-12384 added by P.L. 12-186, effective November 20, 1974.]

§ **12385. Mesh size of fishing nets: net, minimum size.** It shall be unlawful for any person to use net (other than small scoop nets) with a stretched mesh of less than 1½ inch, provided however that:

(a) Persons may use nets of smaller mesh to take only manahac during all months of the year. Manahac is defined as the post-larval stage (total length of less than 2½" of the rabbitfish, Family Teuthididae.)

(b) Persons may use small mesh cast nets (talaya) for the taking of fish other than the manahac during all months of the year.

(c) Persons catching live fish for aquarium purposes may obtain permits from the Director of Agricuture for the use of small mesh nets to capture aquarium type fish only. For purposes of this regulation, the manahac, tiao (juvenile goatfish), ee (juvenile carangid), and aguas (juvenile mullet), are not considered aquarium type fishes. Also a small scoop net is defined as a framed net, usually with a handle attached and the greatest frame opening not exceeding twelve (12) inches.

(d) Persons engaging in tuna fishing may apply for permits from the Director of Agriculture to capture live bait fish such as menis (*Spratelloides sp*), ginyo (*Atherinidae*), fadya (*Engraulidae*), and other suitable bait fish; but will not include the aguas, tiao, ee, and manahac except as allowed by provisions of (a) and (b).

(e) That the above provisions stipulated in (a), (b), (c), and (d) are not applicable in any areas designated as conservation areas where the taking of all seasonal fishes are prohibited.

(f) The native inhabitants shall at all times enjoy their traditional rights to conduct gadi and lalago fishing.

Any violation of this Act shall be punished as prescribed in §§ 12322 and 12323 of the Government Code of Guam. [Added by P.L. 12-215, effective January 29, 1975.]

GOVERNMENT OF GUAM
DEPARTMENT OF AGRICULTURE

REGULATION NO. 28

TAKING OF TROCHUS SHELLS

Pursuant to the authority vested in the Director of Agriculture by Sections 12007 and 12321, Government Code of Guam, the following regulations pertaining to the harvesting of trochus shells (*Trochus niloticus*) are hereby approved:

1. COMMERCIAL HARVEST OF TROCHUS

   a. SEASON: Commercial harvesting of trochus is allowed only during the months of May, June and July.

   b. HARVEST LIMIT: The total harvest limit of trochus shall be set by the Director of Agriculture before each season. Once this total is attained, the season will be closed for the year.

   c. SIZE LIMIT: The commercial harvesting of trochus shall be limited to shells with a base diameter of 4 inches or greater.

   d. AREA: The commercial harvesting of trochus is prohibited shore-ways of the outer edge of the fringing reef. This includes the lagoons and channels that extend shore-ways from the outer edge of the fringing reef.

   e. LICENSE: Each commercial trochus fisherman must obtain a license from the Department of Agriculture. The license fee shall be $5.00.

2. HARVEST OF TROCHUS FOR HOME CONSUMPTION PURPOSES

a. SEASON: For home consumption purposes, the harvesting of trochus shall be allowed all year round.

b. SIZE LIMIT: For home consumption purposes, there will be no size limit except as provided in 2d.

c. AREA: Harvesting of trochus for home consumption is allowed in all areas.

d. BAG LIMIT: For home consumption purposes, each person is allowed no more than 50 pounds (shells included) per day; provided that not more than ten (10) pounds of which shall consist of shells with base diameters of less than two (2) inches.

3. FOR PURPOSES OF THIS REGULATION

a. COMMERCIAL HARVESTING is defined as the harvesting of trochus for the purpose of selling either the shell or the meat.

b. HOME CONSUMPTION is defined as the harvesting of trochus for use as food or other purposes for which no parts thereof are sold.

Dated this 8th day of March, 1968

/s/ Frank B. Aguon
FRANK B. AGUON
Acting Director of Agriculture

AN ECOLOGICAL SURVEY OF PRISTINE TERRESTRIAL COMMUNITIES ON GUAM

Philip H. Moore

August, 1977

This study was funded by a grant from the
Office of Coastal Zone Management, U.S.
Department of Commerce.

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Definition

Terrestrial pristine ecological communities are basically the most untouched representatives of the specific habitats known as limestone forest, ravine forest, savannah, coastal strand and wetlands. These areas are primarily valued as locations of utmost importance for scientific investigation, due to their unique ecological character. Often, they contain some of the most endangered and threatened plant and animal species on the island. The presence of rare, endemic species contributes to the extremely fragile nature of pristine communities and suggests that land and water use must comply with performance standards that are much more rigid, from a conservation perspective, than those which are established for other areas of particular concern.

Methodology

From extensive past fieldwork, the author in coordination with the Guam Coastal Management Program located five of the most unique and pristine communities on the island. Some of these areas are represented by a relationship between two of the distinct natural community types such as ravine forest and savannah. Field transects were necessary for the listing of flora found in each area. Relative incidence was designated as abundant, common, seldom or rare. Fieldwork was conducted between June and September, 1977; thus, incidence may not reflect the annual growth cycle of some herbaceous species. Much of the fauna in these areas, particularly birds, are so reduced in numbers that lists can only be compiled from random siting and past sitings within the communities. Hence, despite the compilation of lists of animals for each area, the flora is the dominant consideration in the delineation of these habitats. The areas were mapped at a scale of 1:400 and the maps included within the written report. Mapping at a scale of 1:25,000 was also provided for the Bureau of Planning. Photographs include some of the most notable scenic views, area features and vegetation found in these pristine communities.

The Plant Communities of Guam

Limestone Forest

The forested areas on the northern half of Guam are now generally regarded as somewhat modified from the original vegetation, except on the virtually inaccessable slopes and terraces found at the north end. In such places, a mixed forest of purely native species can be found which is probably representative of a forest that at one time covered much, or all, of the northern half of the island.

Presently, existing vegetation on the plateau, where man has had the greatest influence, has been altered considerably by the introduction of numerous species which thrive as understory plants in places where native trees such as *Intsia bijuga*, *Artocarpus mariannensis*, and *Elaeocarpus sphaericus* have been cut or thinned out. Such introduced species as *Triphasia trifolia*, *Morinda citrifolia* and *Leucaena leucocephala* grow up quickly to replace the native species and often spread out locally to form nearly pure stands.

In other areas, probably also representing secondary growth or certainly modified growth, nearly pure stands of native plants such as Artocarpus mariannensis, Mammea odorata, Merrilliodendron megacarpum or Cordia subcordata can be found. Unfortunately, this rather odd distribution of native and introduced species is not very clearly understood and establishment of protected areas set aside for study is strongly recommended.

Coastal Strand

The strand is generally thought of as land directly adjacent to the sea or the shoreline. However, because Guam is a rather small island, nearly every species that grows on the strand can also be found inland.

Guam has a fringing reef that extends mostly south from NCS, around the southern end of the island to Pago Bay and across parts of the extreme north end of the island. These parts of Guam contain numerous bays and inlets with long stretches of sandy beach separated by limestone headlands that meet the reef at the water's edge. The remaining shoreline, from Pago Bay north to Pati Point and from Uruno Point south to NCS consists of mostly pitted limestone cliffs fringed by an algal bench with no offshore reef.

In general terms, three types of shoreline can be described: emerged coral limestone or rocky coastline, mangrove/marsh wetlands found at the mouths of rivers and sandy beaches. On emerged limestone, the dominant strand vegetation is Pemphis acidula, Scaevola taccada, Casuarina equisetifolia, and Wedelia biflora with other associated species. These strand plants are salt tolerant and can grow in nutrient deficient soils. The other two types of shoreline are described below.

Wetlands

The wetlands of Guam are confined to the southern half of the island and are mostly coastal; occurring along stream beds where both brackish and freshwater species can be found. In many instances, a remarkably clearcut zonation can be seen where saltwater reed marshes merge into swamp land.

Marshes are generally thought of as places where the water table is permanently at or near the surface and which supports an herbaceous type of vegetation, usually in pure stands. The particular species growing in a given marsh will depend upon depth of water and whether it is freshwater or brackish. When such marsh land becomes invaded by shrubs and trees due to the buildup of sediment they are generally called swamps. Thus, mangrove, Nypa and Hibiscus swamps can be recognized on Guam. A swamp forest of particular interest is the Barringtonia racemosa swamp in the Talofofo River Valley. This is noteworthy because B. racemosa is an endangered plant species and may not occur elsewhere on the island. A description of this and other major swamps can be found in (Moore, Raulerson, Chernin and McMakin, 1977).

Wetlands occur also in the interior, well above sea level, where surface drainage is blocked and water stands for most of the year. A good example of this is a marshy area just east of Mt. Lamlam. Others occur in random distribution on the savannah and can best be seen from the air.

Savannah

Grassland comprises a large portion of the southern volcanic part of the island, particularly the hilly interior which is deeply weathered and dissected by stream erosion. The soil is red, quite acid, and contains very little organic matter. It supports a variety of grasses, the most important of which are *Miscanthus floridulus* (swordgrass), *Dimeria chloridiformis*, and *Pennisetum setosum.* In addition to these, a variety of other herbs, shrubs and small trees occupy the various microhabitats within the grassland community. Examples of this are clumps of *Pandanus tectorius* or *Casuarina equisetifolia* that have somehow escaped for a few years, the annual fires which ravage this community. Also, patches of *Phragmites karka* or *Pennisetum purpureum,* both aquatic grasses, can be found in wet areas where drainage is blocked. Weed communities are common on the savannah where land slides have occurred and a succession of plants have volunteered to cover the scar.

This plant community appears to be controlled by fire, at least in its present condition. An area set aside as a government-controlled conservation preserve and protected by law, or as a pristine ecological community with strictly-enforced performance standards, would provide a location for scientific study that could answer ecological problems of plant succession and distribution that are presently unknown.

Ravine Forest

The volcanic portion of Southern Guam is, in places, deeply dissected by gullies or ravines resulting from stream erosion of weathered volcanic material. Such features are commonly seen from the road in the southern part of the island as components of some of Guam's most unspoiled views.

The vegetation in these areas comprise the ravine forest community and is similar in composition to adjacent forests growing on limestone outcrops. These may be seen on the slopes of Mt. Lamlam or Almagosa; and on the northern limestone plateau.

With few exceptions, the plant species found in ravine forests can also be found on limestone soil. However, there seems to be no species which will not grow elsewhere if planted there. Notable examples of this are *Areca cathecu* (betelnut), *Glochidion marianum, Calophyllum inophyllum,* and *Cerbera dilitata.*

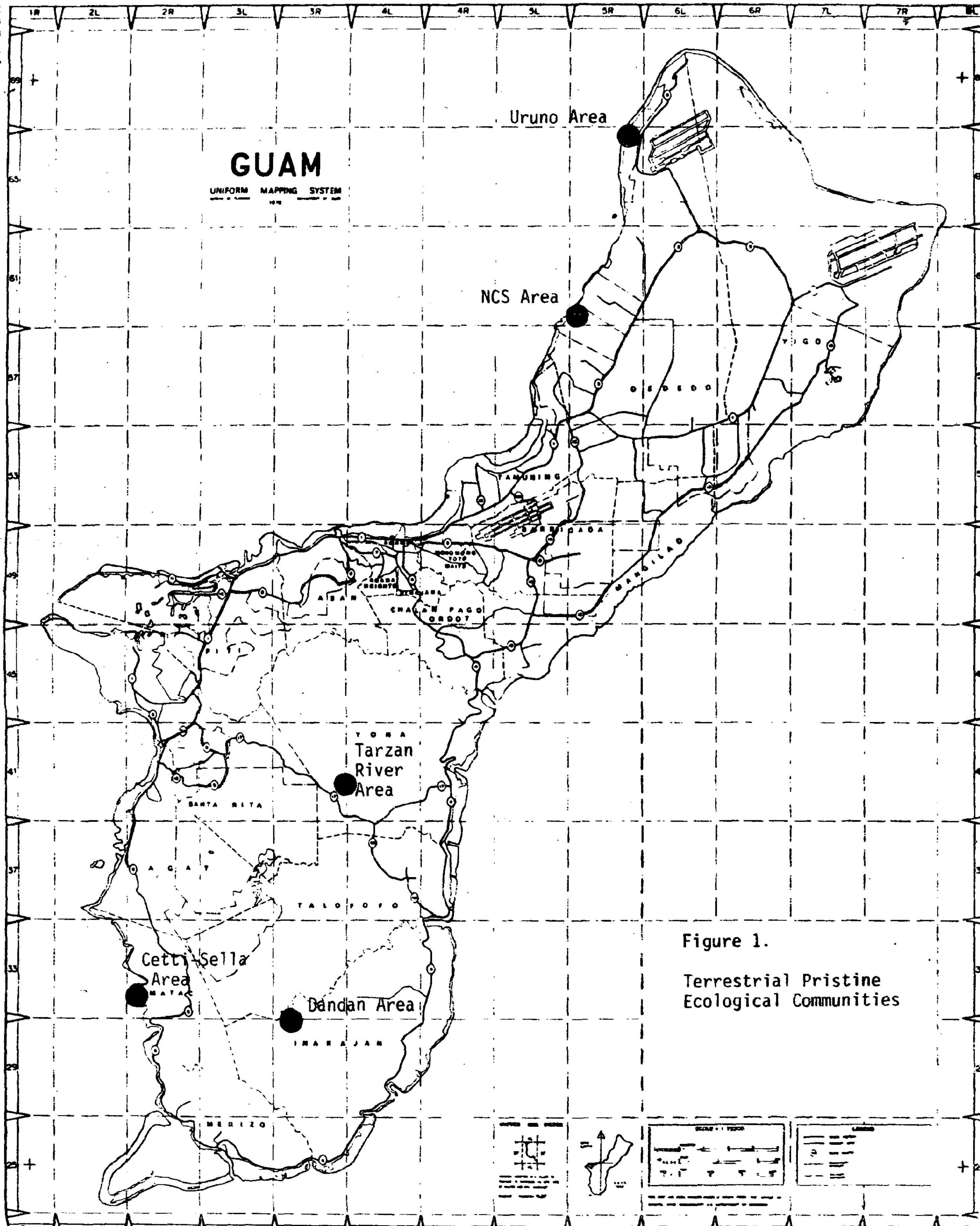


Figure 1.

Terrestrial Pristine Ecological Communities

Uruno Point

The native vegetation of the Uruno area (between Uruno Point and Achae Point) can be divided into four zones (See Figure 2) and is fairly uniform within each zone, with the exception of Zone 2. Zone 1 involves a steep limestone escarpment with little soil and characteristic limestone forest vegetation. The steep and rugged terrain is accessible only by a private trail which should remain in its present state. The forest is in a stage of development short of climax and has been called a "typhoon forest" as it is held indefinitely in this stage due to major typhoons that periodically visit the island.

Zone 2 covers a more gently sloping terrace and may be divided into two segments, roughly north and south of the main trail from the escarpment to the sea. The southern part is covered by a lateritic clay soil to a depth of several inches and supports a diverse flora dominated by Aglaia, Pandanus ssp., Neiosperma and Cycas. The northern part is rocky with very little soil cover. The dominant species here are Triphasia and Cycas with some larger trees here and there. The presence of Triphasia, especially near the first cliffline, indicates a disturbance caused, perhaps, by a recent typhoon. A possible explanation could be that the prominent headland near the southern end of the area protected the southern part while the section north of the headland was exposed to heavy salt spray that killed much of the vegetation that would normally be covering the area. (Environmental Statement Uruno).

Along the lowest terrace, a nearly continuous line of cliffside rock shelters, potsherds, and latte sites give the area a particularly historical and aesthetic appearance. The vegetative interface, that exists here, is a transitional zone between the natural limestone forest and characteristic strand vegetation along the beach. The flora is partly the result of man's subsistence activity and the presence of a sandy gray soil. Ancient taro pits can still be seen as sandy depressions in the land surface indicating the location of a large precontact Chamorro village. Wild taro, Alocasia macrorrhiza, and the introduced coconut palms, Cocos nucifera are dominant species. In areas where firepit activity has enriched the soil with organic material, scattered representatives of limestone forest species can be found. Examples are Piper guahamense, Cycas circinalis, and Pandanus tectorius.

The coastal strand is largely represented by flora which covers white sandy beaches. Dominant species that form the exposed line of beach vegetation are Messerschmidia and Scaevola. A thick tangle of Canavalia maritima and Mucuna gigantea, two leguminous vines, can also be seen along the sandy beach. In areas that are exposed to salt spray near the water's edge, Pemphis, Hedyotis and Bikkia are found growing from exposed rock. Inland from the sandy beach, larger trees of Barringtonia, Mammea, and Thespesia are to be seen. The particularly large Mammea trees found here were badly damaged by Typhoon Pamela.

The entire Uruno area is one of the most untouched examples of limestone forest and is a critical wildlife habitat for endangered species. This is mostly the result of restricted public access through adjacent Air Force property. If access were to be granted to the civilian sector, performance standards or other mechanisms of regulatory enforcement would have to be immediately effective to preserve the existing ecological complexity of the land.

Map No. 1

Uruno Limestone Forest

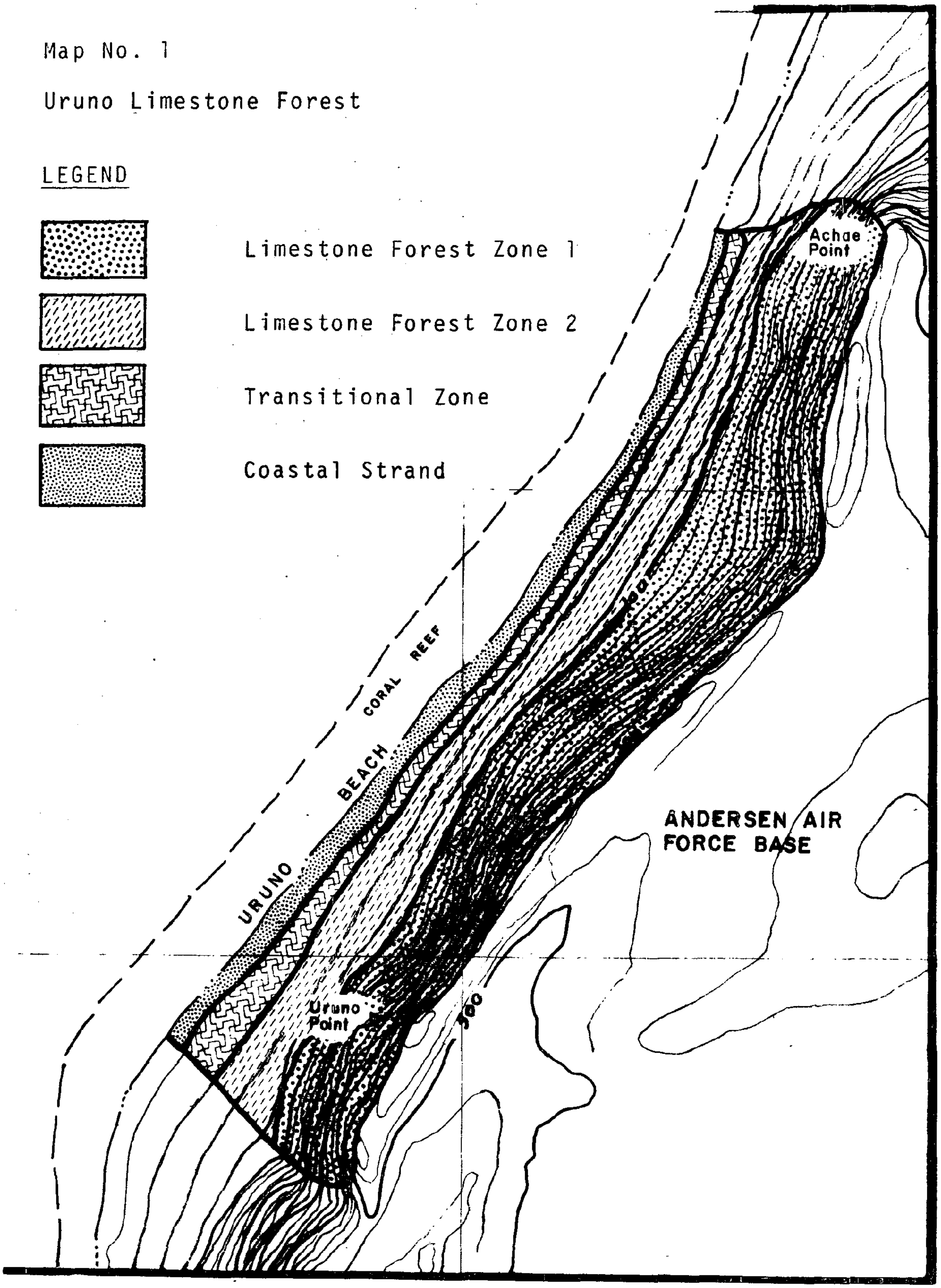


Plate No. 1 Uruno Point Limestone Forest

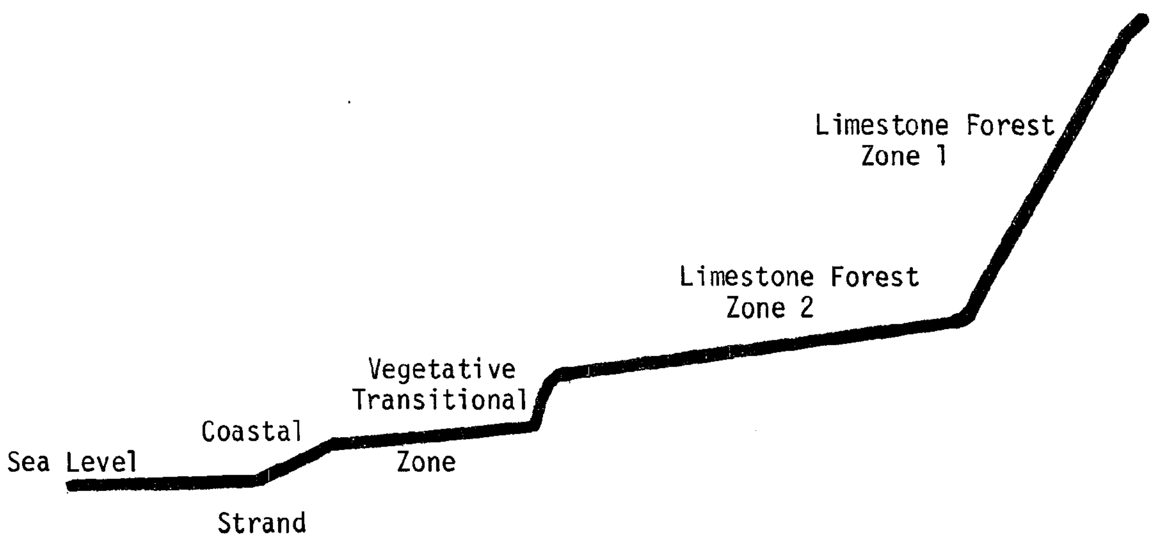


Figure 2. Zonation of Flora and Topography at Uruno

Uruno Limestone Forest Zone 1 Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Aglaia mariannensis		Mapunao	Abundant
Annona reticulata	Sweetsop	Annonas	Common
Artocarpus mariannensis	Infertile Breadfruit	Dugdug	Common
Asplenium nidus	Bird's Nest Fern	Galak Dangkulo	Common
Capsicum frutescens	Hot Pepper	Done Machalek	Seldom
Carica papaya	Papaya	Papaya	Common
Cestrum diurnum	China Inkberry	Tintanchina	Seldom
Claoxylon marianum		Panao, Kator	Common
Cordia subcordata		Niyoron	Abundant
Cycas circinalis	Federico Nut	Fadang	Abundant
Cynometra ramiflora		Gulos	Common
Davallia solida		Pugua machena	Common
Dischidia puberula			Common
Discocalyx megacarpa		Otut	Common
Elatostema calcareum		Tapun Ayuyu	Common
Eugenia javanica	Wax Apple	Makupa	Common
Eugenia reinwardtiana		A'bang	Common
Eugenia thompsonii		Atoto	Seldom
Ficus prolixa	Banyan	Nunu	Common
Ficus tinctoria	Dyer's Fig	Tagete	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Guamia mariannae		Paipai	Common
Guettarda speciosa		Panao	Common
Hernandia nymphaeifolia		Nonak	Common
Intsia bijuga	Ifil	Ifit	Common
Jasminum marianum		Banago	Common
Laportea interrupta		Palilolia	Seldom
Macaranga thompsonii		Pengua	Common
Melanolepis multiglandulosa		Alom	Common
Melochia compacta		Sayafe	Seldom
Microsorum punctatum	Strapleaf Fern	Galak Dikike	Common
Morinda citrifolia	Indian Mulberry	Lada	Common
Neiosperma oppositifolia		Fagot	Abundant
Pandanus dubius	Screwpine	Pahong	Common
Pandanus tectorius	Screwpine	Kafo	Common
Peperomia mariannensis		Potpupot	Common
Phyllanthus marianus		Gaogao Uchan	Common
Phymatodes scolopendria		Kajlao	Common
Piper guahamense	Wild Piper	Pupulu ñ Aniti	Common
Pipturus argenteus		Admahadyan	Seldom
Pisonia grandis		Umumu	Seldom
Planchonella obovata		Lalahak	Common
Polyscias grandiflora		Pepega	Seldom
Premna obtusifolia		Ahgao	Common
Procris pedunculata			Common
Psychotria mariana		Aplokating	Common
Pyrrosia adnascens			Common
Randia cochinchinensis		Sumak	Common
Spathoglottis plicata	Philippine Ground Orchid		Seldom
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Common
Terminalia littoralis		Talisai Ganu	Seldom
Thelypteris interrupta			Common
Vittaria elongata			Seldom

Uruno Limestone Forest Zone 2 Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Aglaia mariannensis		Mapunao	Abundant
Artocarpus mariannensis	Infertile Breadfruit	Dugdug	Common
Asplenium nidus	Bird's Nest Fern	Galak Dangulo	Seldom
Caesalpinia major	Wait-a-bit	Pakao	Seldom
Cordia subcordata		Niyoron	Seldom
Cycas circinalis	Federico Nut	Fadang	Abundant
Davallia solida		Pugua Machena	Seldom
Dioscorea esculenta	Wild Yam	Dago, Nika	Common
Eugenia javanica	Wax Apple	Makupa	Seldom
Eugenia reinwardtiana		A'Abang	Common
Eugenia thompsonii		Atoto	Seldom
Ficus prolixa	Banyan	Nunu	Common
Ficus tinctoria	Dyer's Fig	Tagete	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Guamia mariannae		Paipai	Common
Guettarda speciosa		Panao	Common
Hibiscus tiliaceus		Pago	Common
Intsia bijuga	Ifil	Ifit	Seldom
Ixora triantha			Seldom
Jasminum marianum		Banago	Common
Macaranga thompsonii		Pengua	Common
Maytenus thompsonii		Luluhot	Common
Melanolepis multiglandulosa		Alom	Common
Microsorum punctatum	Strapleaf Fern	Galak Dikike	Common
Morinda citrifolia	Indian Mulberry	Lada	Common
Mucuna gigantea	Small Seabean	Gayi Dikike	Common
Neiosperma oppositifolia		Fagot	Abundant
Pandanus dubius	Screwpine	Pahong	Abundant
Pandanus tectorius	Screwpine	Kafo	Abundant
Phymatodes scolopendria		Kajlao	Common
Piper guahamense	Wild Piper	Pupulu ñ Aniti	Common
Pisonia grandis		Umumu	Seldom
Planchonella obovata		Lalahak	Seldom
Pyrrosia adnascens			Common
Premna obtusifolia		Ahgao	Common
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Common
Triphasia trifolia	Limeberry	Lemondechina	Abundant

Uruno Transitional Zone Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Aglaia mariannensis		Mapunao	Common
Alocasia macrorrhiza	Wild Taro	Piga	Common
Artocarpus mariannensis	Infertile Breadfruit	Dugdug	Common
Bambusa vulgaris	Bamboo	Piao	Seldom
Canavalia maritima		Akangkang Tasi	Common
Capparis cordifolia	Caper	Atkaparas	Rare
Carica papaya	Papaya	Papaya	Common
Cocos nucifera	Coconut	Niyuk	Abundant
Cordia subcordata		Niyoron	Seldom
Cycas circinalis	Federico Nut	Fadang	Abundant
Cynometra ramiflora		Gulos	Common
Elatostema calcareum		Tapun Ayuyu	Common
Eugenia javanica	Wax Apple	Makupa	Seldom
Eugenia reinwardtiana		A'Abang	Seldom
Ficus prolixa	Banyan	Nunu	Common
Ficus tinctoria	Dyer's Fig	Tagete	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Guamia mariannae		Paipai	Common
Guettarda speciosa		Panao	Common
Hernandia nymphaeifolia		Nonak	Abundant
Intsia bijuga	Ifil	Ifit	Seldom
Macaranga thompsonii		Pengua	Seldom
Mammea odorata		Chopak	Common
Maytenus thompsonii		Luluhot	Seldom
Morinda citrifolia	Indian Mulberry	Lada	Common
Neiosperma oppositifolia		Fagot	Common
Pandanus dubius	Screwpine	Pahong	Common
Pandanus tectorius	Screwpine	Kafo	Abundant
Phymatodes scolopendria		Kajlao	Common
Piper guahamense	Wild Piper	Pupulu ñ Aniti	Common
Pisonia grandis		Umumu	Seldom
Premna obtusifolia		Ahgao	Common
Psychotria mariana		Aplokating	Seldom
Pyrrosia adnascens			Common
Randia cochinchinensis		Sumak	Common
Triphasia trifolia	Limeberry	Lemondechina	Common

Uruno Coastal Strand Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Barringtonia asiatica	Fish-kill Tree	Puting	Common
Bikkia mariannensis		Gausali	Common
Bleekeria mariannensis		Langiti	Seldom
Canavalia maritima		Akangkang Tasi	Common
Casuarina equisetifolia	Ironwood	Gago	Seldom
Colubrina asiatica		Gasoso	Common
Hedyotis foetida		Paudedo	Seldom
Hibiscus tiliaceus		Pago	Common
Mammea odorata		Chopak	Common
Messerschmidia argentea	Velvetleaf	Hunik	Abundant
Mucuna gigantea	Small Seabean	Gayi Dikike	Common
Pemphis acidula		Nigas	Common
Scaevola taccada		Nanaso	Abundant
Terminalia littoralis		Talisai Ganu	Rare
Thespesia populnea		Binalo	Common

Uruno Area Fauna

Birds

Corvus kubaryi	Marianas Crow	Aga
Demigretta s. sacra	Reef Heron	
Gallicolumba xanthanura	White-throated Ground Dove	Paluman Fachi
Halycon cinnamomina	Micronesian Kingfisher	Sihig
Phaeton lepturus	White-tailed Tropic Bird	
Ptilinopus roseicapillus	Marianas Fruit Dove	Totot
Rhipidura rufifrons	Rufous-fronted Fantail	Chichirika
Sterna fuscata oahuensis	Sooty Tern	
Streptopelia b. dusumieri	Philippine Turtle Dove	Paluman Senesa
Tringa hypoleucos	Common Sandpiper	

Mammals

Cervus mariannus	Marianas Deer	Binado
Pteropus mariannus	Marianas Fruit Bat	Fanihi
Pteropus tokudae	Little Marianas Fruit Bat	Fanihin Tojo
Suncus murinus	Shrew	Chakan Akaleha
Sus scrofa	Wild Pig	Babui
Rattus sp.	Common Rat	Chaka

Reptiles

Anolis caroliniensis	Green Lizard	
Carlia fuscus	Common Brown Skink	
Emoia collisticta werneri	Blue-tailed Skink	
Hemidactylus frenatus	Common Gecko	
Typhops baraminus	Blind Snake	
Varanus indicus	Monitor Lizard	Hilitai

Amphibians

Bufo marinus	Marine Toad	

Mollusks

Achatina fulica	Giant African Snail	Akahelan Nipponis
Englandina rosea	Pink Predator Snail	Akahela

Crustaceans

Birgus latro	Coconut Crab	Ayuyu
Coenibita sp.	Hermit Crab	Umang, Dukduk

NCS Freshwater Pool Area

This area lies approximately one kilometer north of NCS Beach and the Tanguisson Power Plant along the northeast coast of Guam. It is accessible by walking along the beach and through shoreline paths. The area is comprised of a combination of coastal strand and limestone forest with a unique freshwater pond being located within the limestone forest.

Coastal strand borders the sandy beach between Hilaan Point and a small point of raised limestone, over the narrow reef flat, at the southern perimeter of the bay. The white sand beach is developed in relation to an expansive sand cut, known as Shark Hole, which gives the area an extremely aesthetic appearance.

Federal property ownership and the distance form major traffic circulation has helped keep the area in a pristine condition. However, it is frequented by man for recreational activities such as swimming, fishing, picnicking, hiking, sunbathing and nature observation. Unfortunately, litter is sometimes present and shotgun shell casings attest to occasional poaching for fruit bats, doves and blackbirds in the area. Coconut crabs are also hunted in the evenings along the escarpment that borders the limestone forest.

The exposed limestone that fringes the northern and southern extremes of the coastal strand, hosts a growth of Pemphis. Bikkia is also seen at the northern edge. The salt-tolerant Messerschmidia, known locally as hunik, forms the first line of shrubs along the white sand, with scattered patches of Ipomoea pes-caprae and Wedelia biflora. An occasional Cocos, Barringtonia or Scaevola may also be found here.

Inland of the thin coastal strand, a relatively level zone of gray sandy shioya soil supports a zone of vegetation that represents a distinct interzone or transitional area between the strand and the limestone forest. The dominant species here is Cocos nucifera (coconut palm). Other large trees are common such as Hernandia and Ficus prolixa along with an abundance of small trees and shrubs including Pipturus, Pandanus and Macaranga. The profuse growth of coconut seedlings at this time is probably due to the effects of Typhoon Pamela. Several herbs and terrestrial ferns are abundant in the area between seedlings, the most common of which are Nephrolepis hersutula, Asplenium nidus, and Phymatodes scolopendria.

The limestone forest lies inland, between the steep, rocky escarpment and the vegetative interzone. The limits of this plant community are primarily determined by terrain features. The jungle floor is composed of jagged, eroded limestone that is covered with a very thin layer of soil and organic material. Many species of herbs grow on bare rock with roots extending into numerous crevices for moisture. Shaded by the overhead canopy, the herbs grow on rocks which host a thick carpet of mosses. Among the most prevalent herbs and ground cover vines are Peperomia, Elatostema, Melothria and Nervilia. All of these are used in traditional Chamorro medicines and the area is occasionally used as a collecting site for these species. This location represents one of the few areas where Melothria, known locally as ahgaga, and Nervilia, known locally as seiyaihagun, can be found. The existence of these increasingly endangered species in this area may be due to the isolated location and specialized moisture requirements as well as the relatively low density of giant African snails (Achatina fulica) which have devastated many of Guam's fleshy herbs.

The diverse plant life of the limestone forest does not find any one species of woody trees dominant. Rather, small stands of particular species are clustered amidst the general variety because of seed distribution. The upper canopy is represented by Merrilliodendron, Artocarpus and Ficus prolixa. Guamia, Pandanus tectorius and P. dubius are typical understory plants.

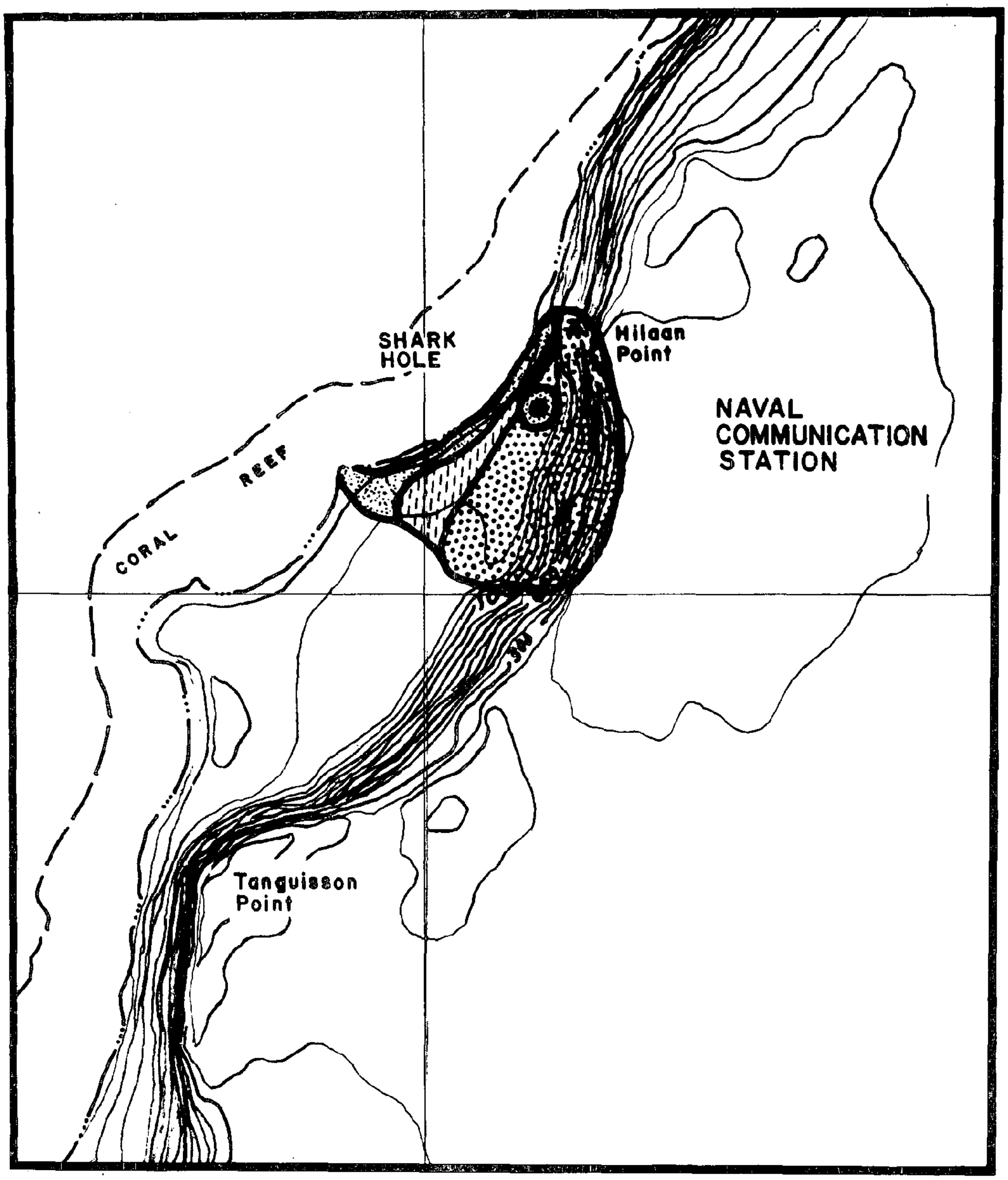
One large and rare Heritiera longipetiolata can be found at the northern edge of the forest along the edge of the escarpment. Another extremely rare species of woody tree, Drypetes dolichocarpa, known locally as lana, was previously sited in this area. Unfortunately, it was killed by Typhoon Pamela. Only three other living trees of this species have been sited on Guam. Also found in the area are Streblus pedulinus and Dendrocnide latifolia both of which are endangered.

Lending a particularly lush appearance to the vegetation in the limestone forest is the thick growth of epiphytic ferns to be seen on the woody trees. The most common are Phymatodes, Davallia, Asplenium nidus and Microsorum. All four of these species are valued in the traditional combination medicines of the local curers, known as suruhanos.

Within the limestone forest, lies a round freshwater pool that is approximately 20 meters in diameter and only 2-3 meters in depth at its deepest point. It is fed by freshwater seeps from the northern Dededo aquifer. Freshwater seeps can be seen along the coastal strand, however, the water collects in this pool because of a shallow depression that remains from a geologic time period when the northern limestone plateau was uplifted by volcanic action. The pool and its fringe area represent a microcosmic plant and animal community that is ecologically unique and of particular aesthetic value. It is the only habitat of its type on Guam as freshwater ponds are not characteristic components of the limestone forest.

The pool hosts a school of cichlid mouthbreeders, Tilapia mossambica, which feed on mosquito and dragonfly larvae and the smaller mosquitofish, Gambusia affinis. A few introduced goldfish-type carp are present and two species of freshwater snails feed on the algae-covered rocks beneath the pond's surface.

The wet fringe of the pond hosts a stand of Acrostichum aureum and Hibiscus tiliaceus, known locally as pago. Several large Merrilliodendron and Ficus prolixa shade the surface of the pond. Two rare and beautiful ferns are seen high in the Merrilliodendrons, the ribbon fern, Ophioglossum pendulum, known locally as leston, and a long, hanging Boston type fern, Nephrolepis acutifolia. Ophioglossum was once very common on Guam. Its present rarity can be attributed to a reduction of habitat and overcollection because it is highly valued as a decorative leaf for religious rituals.



Map No. 2

NCS Freshwater Pool

LEGEND

Limestone Forest

Pool Fringe

Transitional Zone

Coastal Strand

▲ *Heritiera longipetiolata*

Plate No. 2   NCS Area Coastal Strand, Transitional Zone and Limestone Forest

Plate No. 3   NCS Freshwater Pool

NCS Coastal Strand Flora

Taxonomic Classification	Common Name	Chamorro Name	Density
Barringtonia asiatica	Fish-kill Tree	Puting	Seldom
Bikkia pentandra		Gausali	Common
Cocos nucifera	Coconut	Niyuk	Common
Cordia subcordata		Niyoran	Seldom
Hedyotis foetida		Paudedo	Common
Hernandia nymphaeifolia		Nonak	Seldom
Ipomoea pes-caprae	Beach Morning Glory	Alahai Tasi	Common
Messerschmidia argentea		Hunik	Abundant
Pemphis acidula		Nigas	Common
Scaevola taccada		Nanaso	Common
Thespesia populnea		Binalo	Common
Wedelia biflora	Beach Sunflower		Common

NCS Transitional Zone Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Asplenium nidus	Bird's Nest Fern	Galak Dangkulo	Common
Blechum brownei		Jatbas Babui	Common
Canavalia maritima		Akangkang Tasi	Common
Carica papaya	Papaya	Papaya	Common
Cocos nucifera	Coconut	Niyuk	Abundant
Ficus prolixa	Banyan	Nunu	Seldom
Ficus tinctoria	Dyer's Fig	Tagete	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Hernandia nymphaeifolia		Nonak	Common
Ipomoea alba	Moonflower	Alahai	Common
Laportea interrupta			Common
Macaranga thompsonii		Pengua	Seldom
Mikania scandens			Common
Momordica charantia	Bitter Melon	Admagoso	Common
Morinda citrifolia	Indian Mulberry	Lada	Common
Nephrolepis hersutula	Boston Fern		Abundant
Pandanus dubius	Screwpine	Pahong	Seldom
Phymatodes scolopendria		Kajlao	Common
Piper guahamense	Wild Piper	Pupulu ñ Aniti	Seldom
Pipturus argentea		Admahadyan	Common
Pteris tripartita			Common
Pteris vittata	Leatherleaf Fern		Common
Scaevola taccada		Nanaso	Common
Thelypteris interrupta			Common
Triphasia trifolia	Limeberry	Lemondechina	Common

NCS Limestone Forest Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Aglaia mariannensis		Mapunao	Common
Artocarpus altilus	Breadfruit	Lemai	Common
Artocarpus maraiannensis	Infertile Breadfruit	Dugdug	Common
Asplenium falcatum			Seldom
Asplenium nidus	Bird's Nest Fern	Galak Dangkulo	Common
Asplenium pellucidum			Seldom
Barringtonia asiatica	Fish-kill Tree	Puting	Seldom
Capsicum frutescens	Hot Pepper	Done Machalek	Seldom
Carica papaya	Papaya	Papaya	Common
Cycas circinalis	Federico Nut	Fadant	Common
Davallia solida		Pugua Machena	Common
**Dendrocnide latifolia			Seldom
Dioscorea esculenta	Wild Yam	Nika, Gado	Common
Dischidia puberula			Seldom
Elatostema calcareum		Tapun Ayuyu	Common
Eugenia reinwardtiana		A'Abang	Common
Ficus prolixa	Banyan	Nunu	Common
Ficus tinctoria	Dyer's Fig	Tagete	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Guamia mariannae		Pakpak, Paipai	Common
Guettarda speciosa		Panao	Common
*Heritiera longipetiolata		Ufa Halumtano	Rare
Intsia bijuga	Ifil	Ifit	Seldom
Ipomoea alba	Moonflower	Alahai	Common
Jasminum marianum		Banago	Seldom
Macaranga thompsonii		Pengua	Seldom
Melanolepis multiglandulosa		Alom	Common
**Melothria guamensis		Ahgaga	Common
**Merrilliodendron megacarpum		Faniok	Common
Microsorum punctatum	Strapleaf Fern	Galak Dikike	Common
Mikania scandens			Common
Momordica charantia	Bitter Melon	Admagoso	Common
Mucuna gigantea	Small Seabean	Gayi Dikike	Seldom
Neiosperma oppositifolia		Fagot	Common
**Nervilia aragoana	Water-root Orchid	Seiyaihagun	Seldom
Pandanus dubius	Screwpine	Pahong	Common
Pandanus tectorius	Screwpine	Kafo	Common
Peperomia mariannensis		Potpupot	Common
Phymatodes scolopendria		Kajlao	Common
Piper guahamense	Wild piper	Pupulu n Aniti	Common
Pipturus argenteus		Admahadyan	Seldom
Procris pedunculata			Common
Pyrrosia adnascens			Common
**Streblus pedulinus			Seldom
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Common
Thelypteris interrupta			Seldom
Triphasia trifolia	Limeberry	Lemondechina	Common
Vittaria elongata			Seldom

*threatened
**endangered

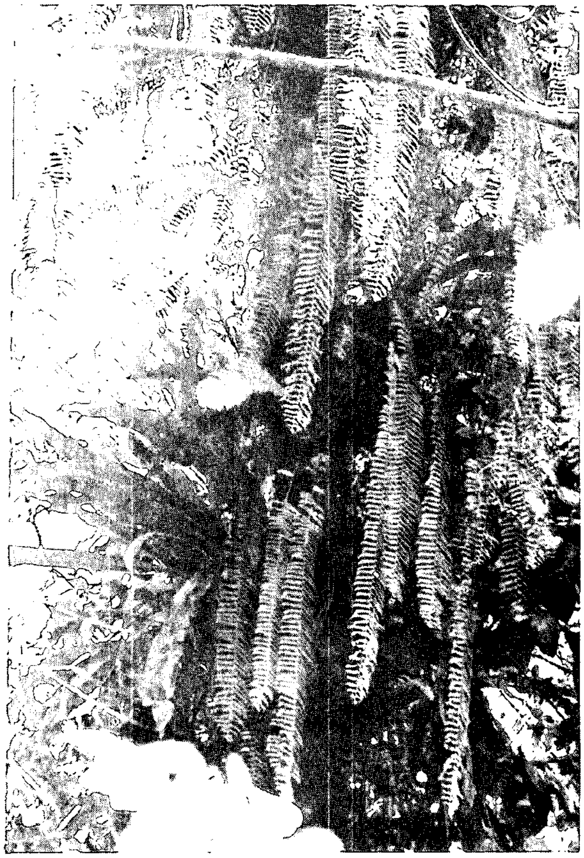


Plate No. 4

Nephrolepis acutifolia

Plate No. 5 Melothria guamensis

NCS Freshwater Pool Fringe Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Acrostichum aureum		Langayao	Abundant
Alocasia macrorrhiza	Wild Taro	Piga	Common
Asplenium nidus	Bird's Nest Fern	Galak Dangkulo	Common
Barringtonia asiatica	Fish-kill Tree	Puting	Seldom
Cocos nucifera	Coconut	Niyuk	Rare
Davallia solida		Pugua Machena	Seldom
Dischidia puberula			Seldom
Elatostema calcareum		Tapun Ayuyu	Common
Ficus prolixa	Banyan	Nunu	Common
Guettarda speciosa		Panao	Common
Hibiscus tiliaceus		Pago	Abundant
Laportea interrupta			Seldom
**Melothria guamensis		Ahgaga	Common
**Merrilliodendron megacarpum		Faniok	Common
Microsorum punctatum	Strapleaf Fern	Galak Dikike	Common
*Nephrolepis acutifolia	Hanging Boston Fern		Rare
**Nervilia aragoana	Water-root Orchid	Seiyaihagun	Common
*Ophioglossum pendulum	Ribbon Fern	Leston	Rare
Pandanus dubius	Screwpine	Pahong	Common
Peperomia mariannensis		Potpupot	Common
Pyrrosia adnascens			Common
Tectaria crenata			Seldom

*threatened
**endangered

NCS Area Fauna

Birds

Corbus kubaryi	Marianas Crow	Aga
Demigretta s. sacra	Reef Heron	
gallicolumba xanthanura	White-throated Ground Dove	Paluman Fachi
Halycon cinnamomina	Micronesian Kingfisher	Sihig
Phaeton lepturus	White-tailed Tropic Bird	
Ptilinopus roseicapillus	Marianas Fruit Dove	Totot
Rhipidura rufifrons	Rufous-fronted Fantail	Chichirika
Sterna fuscata oahuensis	Sooty Tern	
Streptopelia b. dusumieri	Philippine Turtle Dove	Paluman Senesa
Tringa hypoleucos	Common Sandpiper	

Mammals

Cervus mariannus	Marianas Deer	Binado
Pteropus mariannus	Marianas Fruit Bat	Fanihi
Pterpus tokudae	Little Marianas Fruit Bat	Fanihin Tojo
Suncus murinus	Shrew	Chakan Akaleha
Rattus sp.	Common Rat	Chaka

Reptiles

Anolis caroliniensis	Green Lizard	
Carlia fuscus	Common Brown Skink	
Emoia collisticta werneri	Blue-tailed Skink	
Hemidactylus frenatus	Common Gecko	
Tyhops baraminus	Blind Snake	
Varanus indicus	Monitor Lizard	Hilitai

Amphibians

Bufo marinus	Marine Toad	

Fish

Gambusia affinis	Mosquitofish	
Tilapia mossambica	Cichlid	Tilapia
	Goldfish Carp	

Mollusks

Achatina fulica	Giant African Snail	Akahelan Nipponis
Englandina rosea	Pink Predator Snail	Akahela
Melanidae family sp.	Freshwater Snail	
Pulmanate snail	Freshwater Snail	

Crustaceans

Birgus latro	Coconut Crab	Ayuyu
Coenibita sp.	Hermit Crab	Umang, Dukduk

Tarzan River Savannah and Ravine Forest

The area of savannah and associated ravine forest chosen for this study is located in the center of Government Conservation Area No. 3 which is situated in Central-Southern Guam, north of the Fena Valley watershed. The entire area was not considered pristine as it is dissected by Cross-Island Road, unpaved jeep trails, motorcycle paths and reforestation efforts. The random system of roads, motorcycle-induced erosion and abandonment of junk cars have unfortunately claimed portions of what could be a managed wildlife refuge. The delineated pristine area, due to the sloping topography has escaped extensive man-made damage and still represents a valuable ecological community.

The savannah portion of this area encompasses the grassy ridges surrounding the ravine forest described in this report and includes all of the plant species generally associated with the grasslands of southern Guam. Some interesting plants can be found here which indicates past activities by man for the production of useful products. These trees were planted at random and do not represent part of the natural community. A further influence of man is the planting of a few seedlings of flowering shrubs along the main trail to the falls. As with the trees planted in the sterile, eroded soil in adjacent reforestation efforts, introduced trees on the savannah slopes often do not grow well and are eventually displaced by dominant native species, expanding erosion, parasitic species (*Cassytha filiformis*) or simply do not adapt to the harsh conditions.

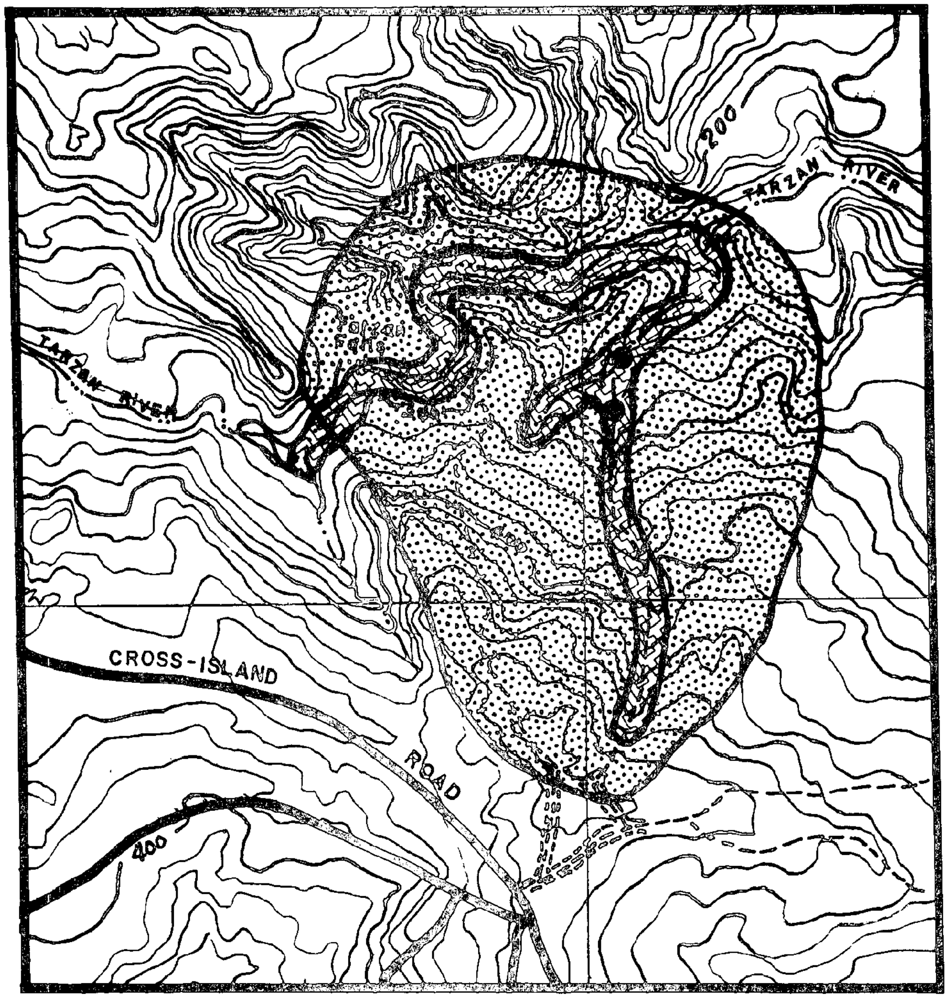
Natural vegetation, such as grasses and ferns, have adapted to savannah conditions and their maintenance is the best method of curtailing erosion. Some erosion is attributed to fires and man-made trails, however, the major eroded area, appearing as bare red scars on the landscape, are the result of natural slumping. The savannah fern, *Dicranopteris linearis*, and dominant grasses such as *Miscanthus floridulus*, *Dimeria chloridiformis* and *Pennisetum setosum* act as major soil binders.

Interspersed among the dominant grasses are numerous small savannah shrubs such as *Decaspermum fruticosum*, *Geniostoma rupestre*, *Timonius nitidus* and *Myrtella bennigseniana*. Taller trees such as *Pandanus* and *Casuarina* occur infrequently until the transitional zone between the savannah and ravine forest is evident. As shown by the list of flora in the transitional zone, the 5-10 meter vegetative zone contains an indistinct mixture of flora which is characteristic of the distinctly separate communities. The dominant species in the transitional zone, with an incidence greater than found in the savannah or ravine forest is *Scleria polycarpa*, a tall sedge.

The major consideration in choosing the Tarzan River ravine forest as a study area is that it contains two mature trees and numerous seedlings of *Serianthes nelsonii*, a rare and endangered endemic species known locally as *hagun laya*. The two trees are located on a little-used path that leads from the upper park area through ravine forest that fringes a small drainage tributary. Water flows through this ravine only during the wet season and empties into the main river just below the falls.

The ravine containing the _Serianthes_ and the Tarzan River ravine are densely wooded with a variety of plant species consisting of trees, shrubs, vines, several ferns and other herbaceous plants. The dominant species at the bottom are _Pandanus tectorius_ and _Hibiscus tiliaceus._ Along the edge of the stream, scattered patches of characteristic wetland species depend on the wet bank for moisture requirements. These include sedges and grasses such as _Fuirena umbellata, Phragmites karka_ and _Eleocharis geniculata._ Numerous ferns, mosses and liverworts can also be found at the water's edge shaded by overhanging vegetation.

The freshwater river and falls is a particularly aesthetic site and hosts eels, shrimp and tilapia as characteristic fauna. Two species of freshwater snails can also be found in the falls area. Most of the birds seen on the adjacent savannah are introduced game species of quail. Few birds are seen in the ravine forest with the exception of an occasional siting of a dove or sparrow. The giant African snail and pink predator snail are present within the ravine forest, however, their numbers are extremely low.



Map No. 3

Tarzan River Ravine Forest
and Savannah

LEGEND

Paved Road

Jeep Road

Hiking Trail

River

SAVANNAH

RAVINE FOREST

Serianthes nelsonii

Plate No. 6 Erosion and Reforestation of Savannah Terrain

Plate No. 7

Tarzan River Ravine Forest

Tarzan River Savannah Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Cassytha filiformis		Mayagas	Common
Casuarina equisetifolia	Ironwood	Gago	Common
Centella asiatica	Pennywort		Common
Cestrum diurnum	China Inkberry	Tintanchina	Common
Curculigo orchioides	Golden-eyed Grass		Seldom
Decaspermum fruticosum			Common
Dianella ensifolia			Seldom
Dicranopteris linearis	Savannah Fern	Mana	Abundant
Dimeria chloridiformis			Abundant
Elephantopus mollis		Papago Vaka	Common
Fimbristylis dichotoma			Abundant
Flagellaria indica	False Rattan	Bejuko Halumtano	Seldom
Geniostoma rupestre		Majlokjayo	Common
Glochidion marianum		Chosga	Common
Hyptis capitata	Buttonweed	Batones	Common
Hyptis pectinata		Mumutong Lahe	Seldom
Leucaena leucocephala		Tangantangan	Seldom
Lycopodium cernuum	Clubmoss		Common
Melastoma marianum		Gafau	Common
Mimosa pudica	Sleeping Grass		Seldom
Miscanthus floridulus	Swordgrass	Neti	Abundant
Myrtella bennigseniana			Common
Nephrolepis sp.	Boston Fern		Seldom
Pandanus tectorius	Screwpine	Kafo	Seldom
Pennisetum setosum			Common
Phyllanthus saffordii			Seldom
Planchonella obovata		Lalahag, Lala	Seldom
Scaevola taccada		Nanaso	Common
Spathoglottis plicata	Philippine Ground Orchid		Common
Stachytarpheta indica			Common
Timonius nitidus		Sumak-Lada	Common
Waltheria americana		Eskobilla Sabana	Common
Wikstroemia elliptica		Gapit Atayake	Common

Tarzan River Transitional Zone Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Alyxia torresiana		Nanago	Seldom
Caesalpinia major	Wait-a-bit	Pakao	Common
Cassytha filiformis		Mayagas	Common
Casuarina equisetifolia	Ironwood	Gago	Common
Centella asiatica	Pennywort		Common
Centotheca lappacea			Common
Cycas circinalis	Federico Nut	Fadang	Common
Davallia solida		Pugua Machena	Common
Decaspermum fruticosum			Common
Dicranopteris linearis	Savannah Fern	Mana	Common
Elephantopus mollis		Papago Vaka	Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Glochidion marianum		Chosga	Common
Hibiscus tiliaceus		Pago	Seldom
Jasminum marianum		Banago	Seldom
Leucaena leucocephala		Tangantangan	Seldom
Morinda citrifolia	Indian Mulberry	Lada	Common
Nephrolepis sp.	Boston Fern		Common
Ochrosia oppositifolia		Fagot	Common
Oplismenus sp.			Common
Pandanus tectorius	Screwpine	Kafo	Common
Phymatodes scolopendria		Kajlao	Seldom
Polygala paniculata			Common
Pyrrosia adnascens			Common
Scaevola taccada		Nanaso	Common
Scleria polycarpa			Abundant
Spathoglottis plicata	Philippine Ground Orchid		Common
*Tacca leontopetaloides	Polynesian Arrowroot	Gapgap	Seldom
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Seldom
Tarenna sambucina		Sumak-Lada	Common
Thelypteris interrupta			Common
Timonius nitidus		Mahalak-Layu	Common
Vittaria elongata			Seldom

*threatened

Tarzan River Ravine Forest Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Areca cathecu	Betelnut	Pugua	Common
Bleekeria mariannensis		Langiti	Common
Casuarina equisetifolia	Ironwood	Gago	Common
Centotheca lappacea			Common
Cerbera dilatata		Chiute	Seldom
Cocos nucifera	Coconut	Niyuk	Seldom
Cycas circinalis	Federico Nut	Fadang	Common
Cynometra ramiflora		Gulos	Common
Cynometra ramiflora			Seldom
Dalbergia candenatensis		Pugua Machena	Common
Davallia solida		Palaga Hilitai	Common
Desmodium umbellatum		Otut	Common
Discocalyx megacarpa			Common
Eleocharis geniculata	Spikerush		Common
Ficus tinctoria	Dyer's Fig	Tagete	Common
Freycinetia reineckei		Fianiti	Common
Fuirena umbellata			Seldom
Hibiscus tiliaceus		Pago	Abundant
Intsia bijuga	Ifil	Ifit	Common
Leucaena leucocephala		Tangantangan	Seldom
Medinilla rosea		Gafus	Common
Mikania scandens			Seldom
Nephrolepis sp.	Boston Fern		Common
Ochrosia oppositifolia		Fagot	Common
Oplismenus sp.			Common
Pandanus tectorius	Screwpine	Kafo	Abundant
Phragmites karka	Reeds	Karriso	Seldom
Piper guahamense	Wild Piper	Pupulu h Aniti	Common
Premna obtusifolia		Ahgao	Common
Pyrrosia adnascens			Common
Scleria polycarpa			Abundant
**Serianthes nelsonii		Hayun Lago	Rare
Spathoglottis plicata	Philippine Ground Orchid		Common
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Common
Thelypteris interrupta			Common
Triphasia trifolia	Limeberry	Lemondechina	Common
Vittaria elongata			Common
**Xylosma nelsonii			Seldom

**endangered

Tarzan River Area Fauna

Birds

Coturnix chinensis	Chinese Painted Quail	
Excalfactoria sinensis	Pygmy Quail	
Padda oryzivora	Java Sparrow	
Streptopelia b. dusumieri	Philippine Turtle Dove	Paluman Senesa

Mammals

Suncus murinus	Shrew	Chakan Akaleha

Reptiles

Carlia fuscus	Common Brown Skink	
Emoia collisticta werneri	Blue-tailed Skink	

Amphibians

Bufo marinus	Marine Toad	

Fish

Anguilla marmorata	Freshwater Eel	Hasule
Tilapia mossambica	Cichlid	Tilapia

Mollusks

Achatina fulica	Giant African Snail	Akalehan Nipponis
Englandina rosea	Pink Predator Snail	Akaleha
Neritina pulligera	Freshwater Nerite	
Melanidae family sp.	Freshwater Snail	

Crustaceans

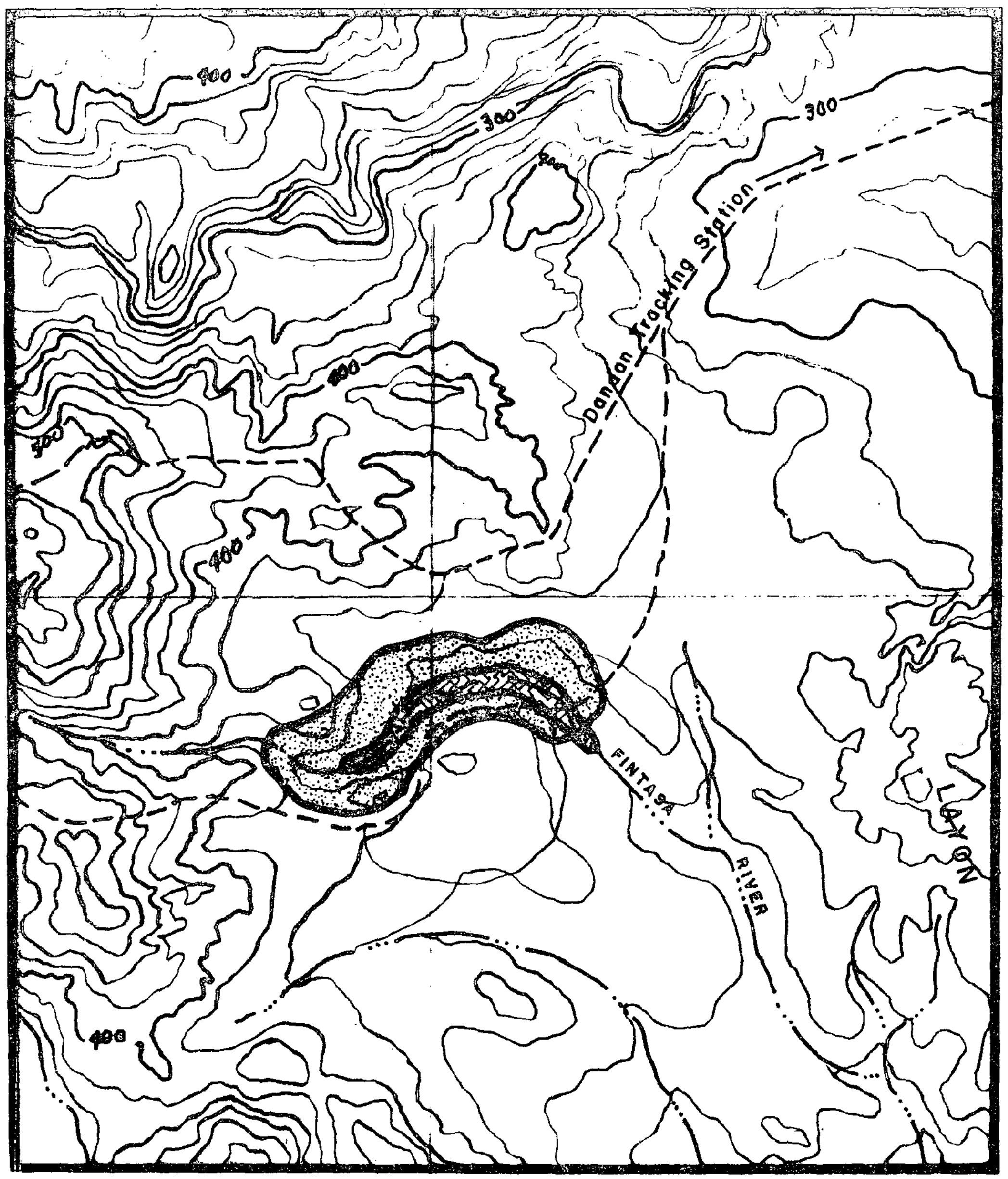
Macrobrachium lar	Freshwater Shrimp	Uhang

The Dandan Marsh Wetland Area

The wetland chosen for this study is located on the central-southeast side of the island in the Dandan area. It can be reached by following a jeep trail from the Dandan Nasa Tracking Station, approximately three kilometers inland towards the Umatac volcanic formation. The reed marsh occurs on high land between two ridges where surface drainage collects and stands for most of the year. A jeep road crosses the southern tip of the marsh. Drainage pipes, installed under the road, are not low enough to drain the area.

The marsh has very little open water, the center being choked with reeds and associated grasses and sedges. Phragmites karka, a tall reed-like grass, is indicative of water at or very near the surface and forms thick stands along the fringes both up and down river of the main marsh area. A variety of shrubs, generally associated with wetlands,occur at the edges and merges into the savannah community.

An interesting sedge, Eleocharis dulcis, known locally as uchaga-lane or ground chestnut, grows as the dominant species in a nearly pure stand in the marsh area that is most heavily and consistently inundated with water. This Asiatic species has an edible, tuberous root and was probably introduced to Guam. There is no evidence that it is presently being harvested as a source of food.



Map No. 4

Dandan Marsh Wetland
and Savannah

LEGEND

Jeep Road

River

Reed Marsh

Savannah

Plate No. 8   Dandan Reed Marsh and Surrounding Savannah

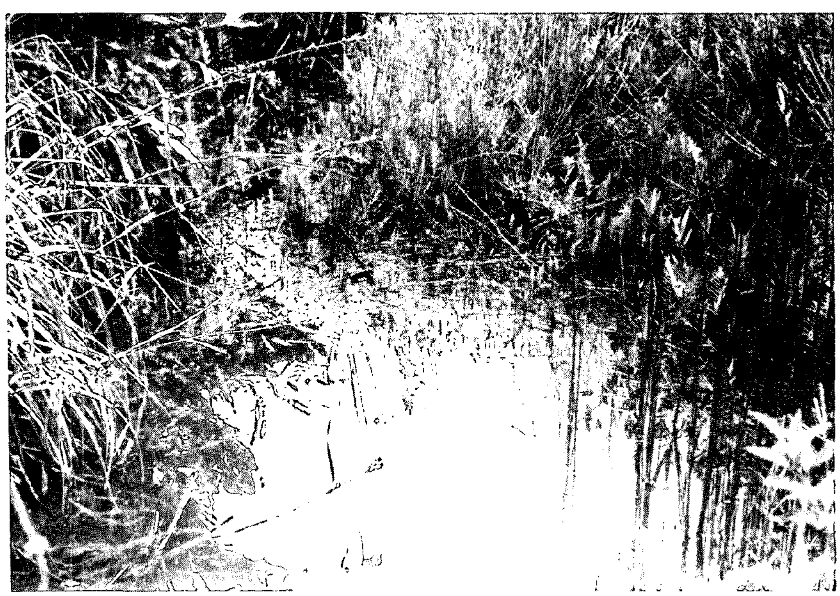


Plate No. 9   Close-up of Marsh Wetland Vegetation

Dandan Marsh Wetland Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Acrostichum aureum		Langayao	Common
Barringtonia samoensis			Seldom
Cyperus odoratus			Common
Eleocharis dulcis	Water Nut	Uchaga Lane	Abundant
Eleocharis geniculata	Spike Rush		Common
Fimbristylis dichotoma			Common
Hibiscus tiliaceus		Pago	Common
Nephrolepis hirsutula	Boston Fern		Abundant
Phragmites karka	Reeds	Karriso	Abundant
Pteris vittata	Leatherleaf Fern		Abundant
Rhynchospora corymbosa		Chachachak	Common
Scirpus fuirena			Common
Scirpus littoralis	Bullrush		Common

Dandan Area Savannah Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Bidens pilosa	Beggar's Tick		Seldom
Brachiaria mutica	Para Grass		Common
Cassytha filiformis		Mayagas	Common
Centella asiatica			Seldom
Cycas circinalis	Federico Nut	Fadang	Seldom
Decaspermum fruticosum			Common
Dicranopterus linearis	Savannah Fern	Mana	Abundant
Dimeria chloridiformis			Abundant
Elephantopus mollis		Papago Vaka	Abundant
Eleusine indica	Crow's Foot Grass	Chaguan Kabayo	Seldom
Geniostoma rupestre		Majlokjayo	Common
Glochidion marianum		Chosga	Common
Hyptis capitata	Buttonweed	Batones	Abundant
Hyptis pectinata		Mumutong Lahe	Common
Leucaena leucocephala		Tangantangan	Common
Lycopodium cernum	Clubmoss		Abundant
Lygodium scandens			Common
Melastoma marianum		Gafau	Common
Miscanthus floridulus	Swordgrass	Neti	Abundant
Mikania scandens			Common
Mimosa pudica	Sleeping Grass		Common
Morinda citrifolia	Indian Mulberry	Lada	Seldom
Myrtella bennigseniana			Common
Pandanus tectorius	Screwpine	Kafo	Seldom
Passiflora foetida	Love-in-a-mist	Kinahulo Adao	Seldom
Pennisetum setosum			Abundant
Phyllanthus saffordii			Seldom
Polygala paniculata			Common
Psidium guajava	Guava	Abas	Seldom
Pyrrosia adnascens			Common
Sida rhombifolia			Common
Spathoglottis plicata	Philippine Ground Orchid		Common
Stachytarpheta indica			Common
Urena lobata		Dadangse	Common
Wikstroemia elliptica		Gapit Atayake	Seldom

Dandan Area Fauna

Birds

Coturnix chinensis	Chinese Painted Quail	
Excalfactoria sinensis	Pygmy Quail	
Ixobrychus sinensis	Chinese Least Bittern	Kakag
Padda oryzivora	Java Sparrow	
Streptopelia b. dusumieri	Philippine Turtle Dove	Paluman Senesa

Mammals

Cervus mariannus	Marianas Deer	Binado

Reptiles

Carlia fuscus	Common Brown Skink	
Emoia collisticta werneri	Blue-tailed Skink	

Amphibians

Bufo marinus	Marine Toad	

Fish

Anquilla marmorata	Freshwater Eel	Hasule

Crustaceans

Macrobrachium lar	Freshwater Shrimp	Uhang

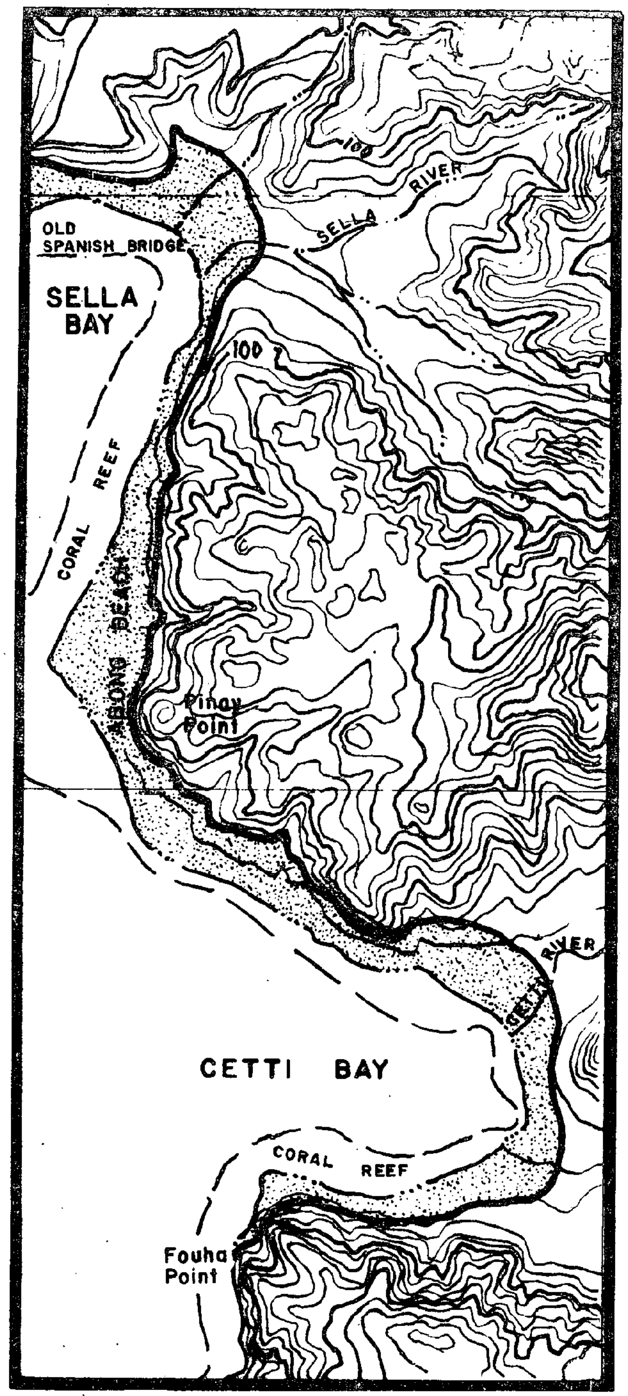
Cetti-Sella Bay Coastal Strand

The area chosen as an example of a pristine strand community is the Cetti-Sella Bay region of the southeast coast. It was deemed most appropriate because it includes a long stretch of sandy beach shoreline, estuarine bays and small rocky portions of coastline.

The strand directly behind the beach, along the sandy coast and within the bays themselves, is occupied by a rich variety of plants dominated by Cocos nucifera, Hibiscus tiliaceus, Thespesia populnea, Hernandia nymphaeifolia and numerous other smaller shrubs, vines, ferns and other herbs. Patches of beach morning glory or Ipomoea pes-caprae, known locally as alahai tasi and Sporobolus virginicus, (salt grass or totoput), both valued as traditional medicinal plants, cover portions of the sandy beach as the dominant ground cover. In areas of exposed volcanic rock, Pemphis acidula and Casuarina equisetifolia provide the sole vegetative cover along the strand.

A small stream empties into each bay and typical estuarine flora and fauna are found there. Tilapia and the freshwater shrimp (Macrobrachium lar) are found in the streams which drain from the upland ravine forest and savannah. Numerous hermit crabs scavenge along the coastal strand, as well as an occasional land crab (Cardisoma carnifex). The introduced monitor lizard (Varanus indicus), known locally as hilitai has been sited along the streams and probably utilizes the common rat as its main source of food. Few birds, other than transient shore birds are to be seen in the area.

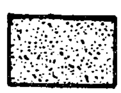
From the main road, the Cetti-Sella coastal strand, ravine forest and savannah provide one of the most beautiful and frequently photographed areas on the island. Additional attractions along the strand consist of an old Spanish bridge, constructed of hand-hewn stones, which spans the Sella River. The remains of a beehive-type oven of Mexican origin and precontact archaeological sties are also present. Of particular geologic significance is a volcanic stack on the reef flat just south of Sella Bay.



Map No. 5

Cetti-Sella Coastal Strand

LEGEND



Coastal Strand

Plate No. 10 Cetti-Sella Coastal Strand and Volcanic Stack

Plate No. 11 Sella River Spanish Bridge

Sella-Cetti Coastal Strand Flora

Taxonomic Classification	English Name	Chamorro Name	Density
Alocasia macrorrhiza	Wild Taro	Piga	Common
Annona muricata	Soursop	Laguanaha	Common
Areca cathecu	Betelnut	Pugua	Seldom
Artocarpus altilus	Breadfruit	Lemai	Common
Bidens pilosa	Beggar's Tick		Common
Blechum brownei		Jatbas Babui	Common
Callicarpa candicans		Masigsig	Seldom
Canavalia maritima		Akangkang Tasi	Common
Carica papaya	Papaya	Papaya	Common
Casuarina equisetifolia	Ironwood	Gago	Common
Cocos nucifera	Coconut	Niyuk	Abundant
Cycas circinalis	Federico Nut	Fadang	Seldom
Davallia solida		Pugua Machena	Seldom
Dalbergia candenatensis			Rare
Desmodium umbellatum		Palaga Hilitai	Common
Eleocharis sp.			Common
Elephantopus mollis		Papago Vaka	Common
Entada pursaetha	Large Seabean	Gayi Dangkulo	Seldom
Euphorbia chamissonis			Common
Flagellaria indica	False Rattan	Bejuko Halumtano	Common
Heritiera littoralis		Ufa	Seldom
Hernandia nymphaeifolia		Nonak	Common
Hibiscus tiliaceus		Pago	Abundant
Hymenocallis littoralis	Spider Lily		Common
Ipomoea alba	Moonflower	Alahai	Common
Ipomoea pes-caprae	Beach Morning Glory	Alahai Tasi	Abundant
Leucaena leucocephala		Tangantangan	Common
Mangifera indica	Mango	Manga	Seldom
Microsorum punctatum	Strapleaf Fern	Galak Dikike	Common
Mikania scandens			Common
Miscanthus floridulus	Swordgrass	Neti	Common
Morinda citrifolia	Indian Mulberry	Lada	Common
Musa sapientum	Banana	Chotda	Seldom
Nephrolepis sp.	Boston Fern		Common
Pandanus dubius	Screwpine	Pahong	Seldom
Pandanus tectorius	Screwpine	Kafo	Common
Passiflora foetida	Love-in-a-mist	Kinahulo Adao	Common
Pemphis acidula		Nigas	Abundant
Pennisetum setosum			Common
Phymatodes scolopendria		Kajlao	Common
Polygala paniculata			Common
Pteris vittata			Common
Pyrrosia adnascens			Common
Scaevola taccada		Nanaso	Common
Sesbania cannabina			Seldom
Sporobolus virginicus	Salt Grass	Totoput	Common
Stachytarpheta indica			Common
Taeniophyllum mariannense	Leafless Orchid	Sanyeye	Common
Teramnus labialis		Chaguan Kakaguates	Common
Thespesia populnea		Binalo	Common
Triphasia trifolia	Limeberry	Lemondechina	Common
Urena lobata		Dadangse	Common
*Vigna marina		Akangkang Marilasa	Rare

*threatened

Sella-Cetti Area Fauna

Birds

Annous stolidus pileatus	Common Noddy Tern	Fahan
Demigretta s. sacra	Reef Heron	
Sterna fuscata oahuensis	Sooty Tern	
Streptopelia b. dusumieri	Philippine Turtle Dove	Paluman Fachi
Tringa hypoleucos	Common Sandpiper	

Mammals

Suncus murinus	Shrew	Chakan akaleha
Rattus sp.	Common Rat	Chaka

Reptiles

Anolis caroliniensis	Green Lizard	
Carlia fuscus	Common Brown Skink	
Emoia collisticta werneri	Blue-tailed Skink	
Hemidactylus frenatus	Common Gecko	
Typhops baraminus	Blind Snake	
Varanus indicus	Monitor Lizard	Hilitai

Amphibians

Bufo marinus	Marine Toad	

Crustaceans

Cardisoma carnifex	Land Crab	Panglao
Coenibita sp.	Hermit Crab	Umang, Dukduk

Recommended Performance Standards

1. Scientific investigation of the ecological complexity of pristine areas should be their primary use. It is generally recognized that the mysteries of natural history are far from being all discovered and future generations will not have any living laboratories for study unless natural areas are preserved.

2. Plant collection, soil removal, landfill and rock collection should be prohibited within pristine areas. Overzealous collection of souvenirs, houseplants, sand and topsoil, as well as the more destructive land grading or landfilling can severely damage the natural processes within a pristine area. The only exception would be the limited collection of plants for laboratory analysis or identification or the cultural use of medicinal plants by local curers. The practice of the suruhano curers is declining, thus over collection of species for medicinal purposes is not foreseen as a major problem.

3. Recreational activities should be encouraged, but limited to hiking on designated trails for purposes of nature observation and photography. Overnight camping, campfires, restrooms, litter, picnicking, hunting and fishing should be prohibited. Other larger recreational parks and open space, rather than fragile pristine areas, are available for extensive recreation.

4. Structural developments other than minimal hiking trails, benches, steps or small identification markers should be prohibited. There should be no off-road vehicular traffic such as motorcycles, jeeps, cars, etc. Vehicles are totally inconsistent with the nature of pristine areas.

5. Alteration of the natural ecological relationships should be discouraged. Exceptions might be:

    a. carefully controlled eradication of detrimental, introduced species which could severely disrupt the area ecology.

    b. reforestation of fire or erosion-damaged areas with emphasis on planting endemic species characteristic of the plant community.

    c. strategic re-planting of endangered tree seedlings when it is evident that they will be too sheltered by the parent tree or displaced by other vegetation.

6. The Division of Aquatic and Wildlife Resources and the Forestry Division within the Department of Agriculture should be the primary agents for monitoring pristine areas and actively enforcing established regulations which are designed to manage human interaction with natural habitats.

Appendix No. 1 Endangered and Threatened Plant Species on Guam*

A. Endangered Species - taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.**

B. Threatened Species - taxa believed likely to move into the endangered category in the near future if serious adverse factors continue operating.

Endangered Species

Alyxia torresiana
Angiopteris durvilleana
Barringtonia samoensis
Barringtonia racemosa
Calanthe furcata
Canthium odoratum
Capparis cordifolia
Cyathea lunulata
Derringia amaranthoides
Dendrocnide latifolia
Dodonaea viscosa
Drypetes dolichocarpa
Eugenia bryanii
Excoecaria agalocha
Fagraea galilai
Grewia crenata
Hernandia labyrinthica
Lycopodium phlegmaria
Maesa sp.
Melothria guamensis
Merrilliodendron megacarpum
Morinda umbellata
Myoporum boninense
Nervilia aragoana
Pisonia umbellifera
Portulaca pilosa
Potamogeton lucens
Psychotria rotensis
Serianthes nelsonii
Streblus pendulinus
Strongylodon sp.
Tabernaemontana rotensis
Tarenna sambucina
Terminalia littoralis
Trema orientalis var. viridis
Tristiropsis acutangula
Xylosma nelsonii

Threatened Species

Avicennia marina var. alba
Bruguiera gymnorrhiza
Cerbera dilitata
Elaeocarpus sphaericus
Heritiera longipetiolata
Leucaena insularum var. guamense
Lumnitzera littorea
Nephrolepis acutifolia
Ophioglossum pendulum
Rhizophora apiculata
Rhizophora mucronata
Suriana maritima
Tacca leontopetaloides
Vigna marina

*List prepared by Philip H. Moore.

** Red Data Book Categories, International Union for the Conservation of Nature

Appendix No. 2 Endangered and Threatened Animal Species on Guam*

Endangered Birds

Sula leucogaster	Brown Booby	Luan
Phaeton lepturus	White-tailed Tropic Bird	
Egretta sacra	Reef Egret	Chuchuko
Gallinula chloropus	Common Gallinule	Pulatat
Gygis alba	White Fern	Chunge
Ptilinopus roseicapillus	Marianas Fruit Dove	Totot
Gallicolumba xanthanura	White-throated Ground Dove	Paluman fachi
Halcyon cinnamomina	Micronesian Kingfisher	Sihig
Anas oustaleti	Marianas Mallard	Nganga
Acrocephalus luscinia	Nightingale Reed Warbler	Ga-kirriso
Collocalia vanikorensis	Vanikoro Swiftlet	Jajaguag, Pagaga
Rhipidura rufifrons	Rufous-fronted Fantail	Chichirika
Myiagra oceanica	Micronesian Broadbill	Chiguaguan
Corvus kubaryi	Marianas Crow	Aga
Myzomela cardinalis	Cardinal Honey-eater	Egigi
Zosterops conspicillata	Bridled White-eye	Nossak
Poliolimnas cinereus	White-browed Rail	Bako

Threatened Birds

Rallus owstoni	Guam Rail	Koko
Aplonis opacus	Micronesian Starling	Sali
Ixobrychus sinensis	Chinese Least Bittern	Kakkag
Anous stolidus	Common Noddy	Fahan

Endangered Mammals

Bubalus bubalis	Asiatic Water Buffalo	Karabao
Emballanura semicaudata	Short-tailed Emballanura	
Pteropus tokudae	Little Marianas Fruit Bat	Fanihi Tojo
Pteropus mariannus	Marianas Fruit Bat	Fanihi

Endangered Reptiles

Eretmochelys imbricata	Hawksbill Turtle	Haga Karai
Chelonia mydas	Green Turtle	Hagan Verde
Emoia slevini		
Perochirus aciculatus	Cocos Island Gecko	

Threatened Reptiles

Lepidodactylus lugabris	Gecko	

*List prepared by the Endangered and Threatened Species Committee of Guam, 1976.

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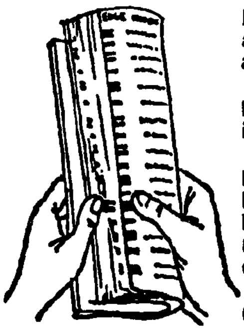

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