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TERN ISLAND STUDY

VOLUME ONE - MAIN REPORT

JUNE, 1979

MANTA CORPORATION

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TERN ISLAND STUDY

Final Report

Volume One - Main Report

June, 1979

Prepared On Contract To The Dept. of Interior

Fish and Wildlife Service

MARINE RESEARCH · COMMERCIAL FISHING

THE MANTA · PIER 202, KEWALO BASIN OR 272 SOUTH KALAHEO ST., KAILUA, HAWAII 96734 · 261 · 4959

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INTRODUCTION

French Frigate Shoals (FFS) is a coral atoll situated almost at the midpoint of the 1600 mile long Hawaiian archipelago. Tern Island is one of 13 small named islands in FFS. As such, the island is considered by the Federal government to be a federally-owned segment of the Hawaiian Islands National Wildlife Refuge (HINWR). In 1942, the original 11 acre islet was converted into an airstrip to support naval operations during World War II. Excepting a period of intermittent use between 1946-1952, the island has been continuously inhabited by military personnel since its construction. The U.S. Coast Guard has operated a LORAN-A station at FFS since 1944, first at East Island and after 1952, at Tern Island. Operation of the LORAN station within the HINWR has been conducted under a Cooperative Agreement between the U.S. Coast Guard and the Bureau of Sport Fisheries and Wildlife (now Fish and Wildlife Service) signed in March, 1967. On 30 June, 1979 the Coast Guard plans to disestablish the LORAN station at Tern Island.

In order to make a wise decision regarding future management of the island, FWS contracted MANTA Corporation on 15 March 1979 to evaluate various management options for Tern Island. The data gathering phase of the "TERN ISLAND STUDY" has involved interviews with knowledgeable persons and review of pertinent published and unpublished literature and other documents. The information gathered is to be used by the FWS in its continuing assessment process. It should be noted that the decision regarding future management of Tern Island is a very controversial one, complicated by a continuing dispute regarding refuge boundaries and a regrettable shortage of pertinent data to objectively evaluate the short and long range impacts of various management options. The range of viable options is also constrained to some degree by legal and institutional considerations.

It is not our intent to make specific long range management recommendations at the conclusion of this study. However, it is possible to point out the immediate and potential effects of various management decisions. It is also our intent to identify where signficant data gaps lessen the predictability of impacts and the manner in which a Tern Island management decision is interrelated with other unsettled issues.

It is virtually certain that our discussion of impacts will provoke discussion, debate and perhaps even violent disagreement. The science of impact prediction is in its infancy and in its early stages is dependent to a large degree upon indirect evidence. This is particularly true in this study, which is lacking in precedent in many ways. The biological, socioeconomic and legal ramifications of a Tern Island management decision at this time will extend far beyond the geographic limits of Tern Island and French Frigate Shoals. The underlying question throughout this study relates to the degree to which commercial exploitation of marine resources in the Northwestern Hawaiian Islands is compatible with wildlife conservation. This question is a primary focal point of the ongoing Tripartite Cooperative Agreement of the Northwestern Hawaiian Islands, and our report does not pretend to second guess the results of the Tripartite study with premature conclusions. On the other hand, interim management decisions for Tern Island must be made soon and should be as firmly grounded in fact as possible.

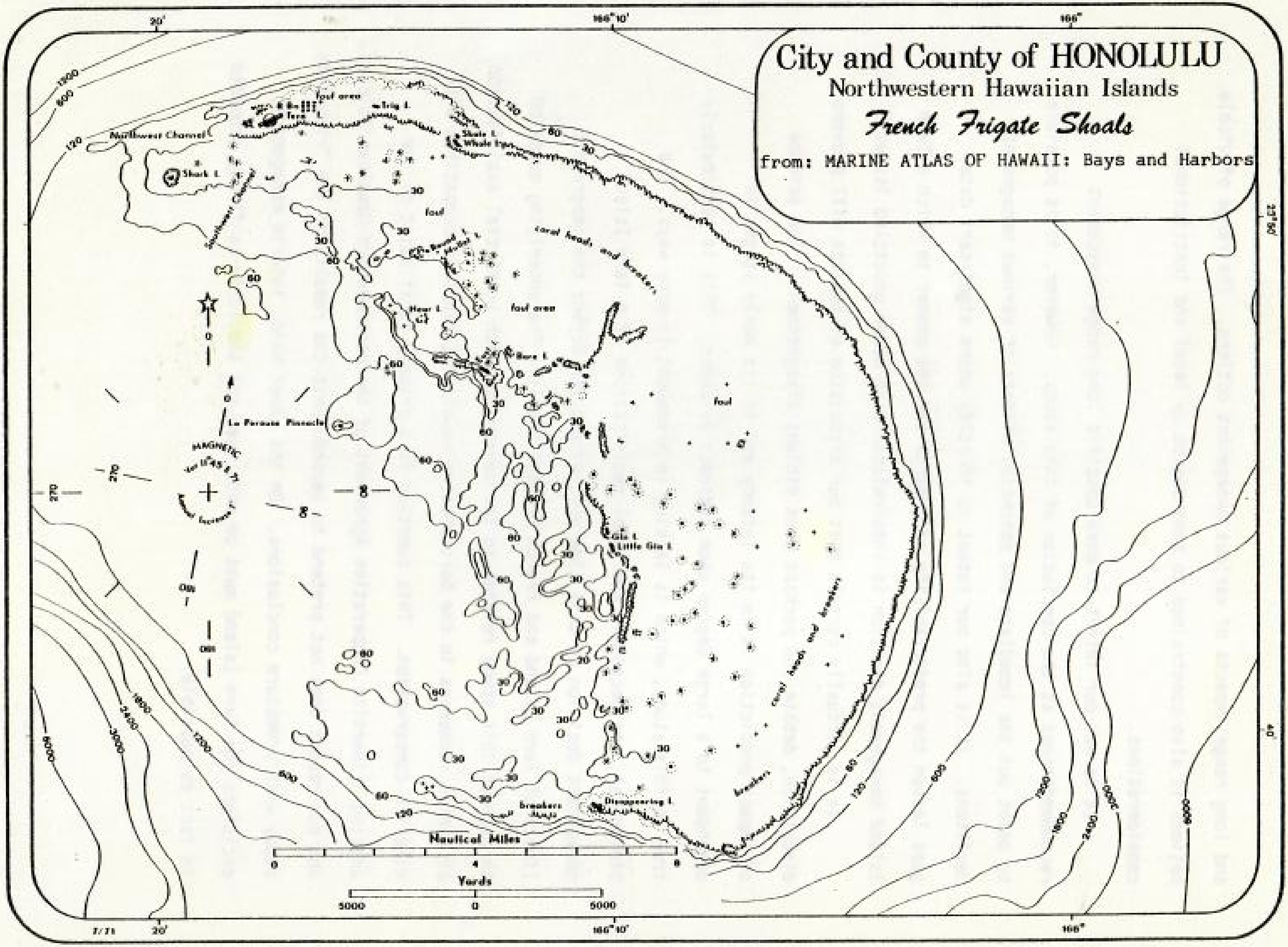
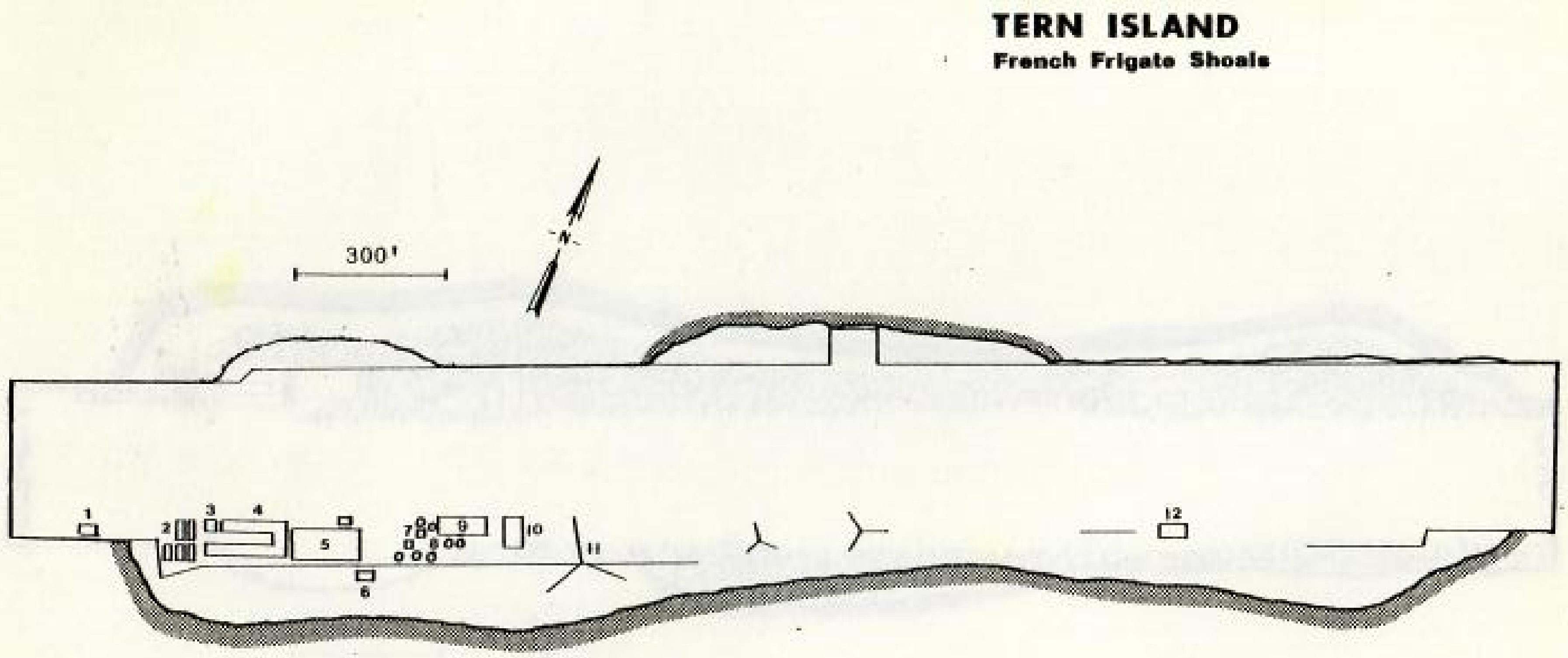


Figure 4 French Frigate Shoals, Northwestern Hawaiian Islands, City & County of Honolulu, State of Hawaii.



1. Boat House
2. Fuel Oil Storage Tanks
3. Garage
4. Barracks-Subsistence Bldg.
5. Recreation Court
6. Playboy Club
7. Pump House
8. Fresh Water Tanks
9. Signal Power Bldg.
10. Old Signal Power Bldg.
11. Loran-A Transmitting Antenna
12. Storage Building

Figure 2 Tern Island - existing structures.

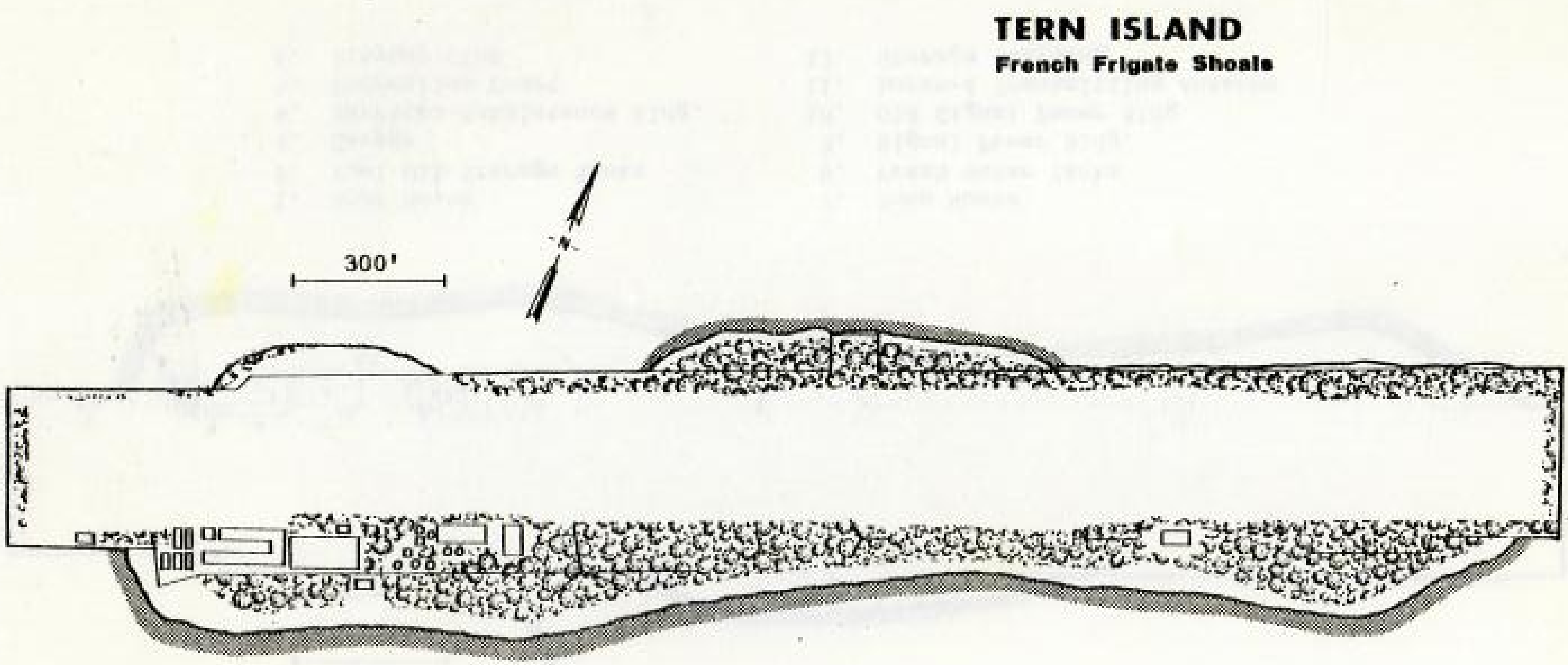


Figure 3. Tern Island - extent of vegetation.

Figure 4. Outer Reef, French Frigate Shoals.

Figure 5. Whale-Skate Island, French Frigate Shoals.

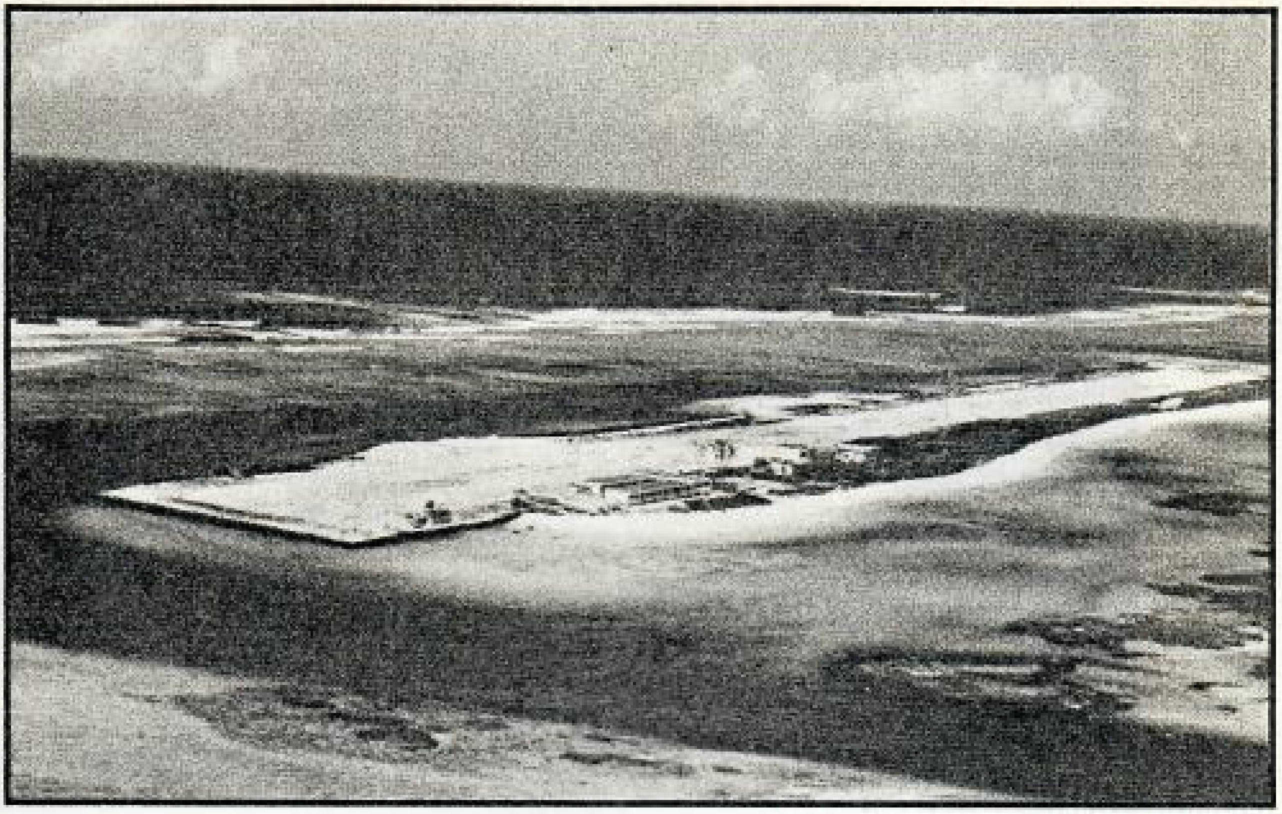


Figure 6. Tern Island - west end in foreground; note dredged channel and turning basin.

Figure 7. Tern Island - U.S. Coast Guard living quarters.

Figure 8. Tern Island - principal area of vegetation along south side of runway.

Figure 9. Tern Island - Sooty Tern colony, east end of runway.

Figure 10. Tern Island - northeast corner of island.

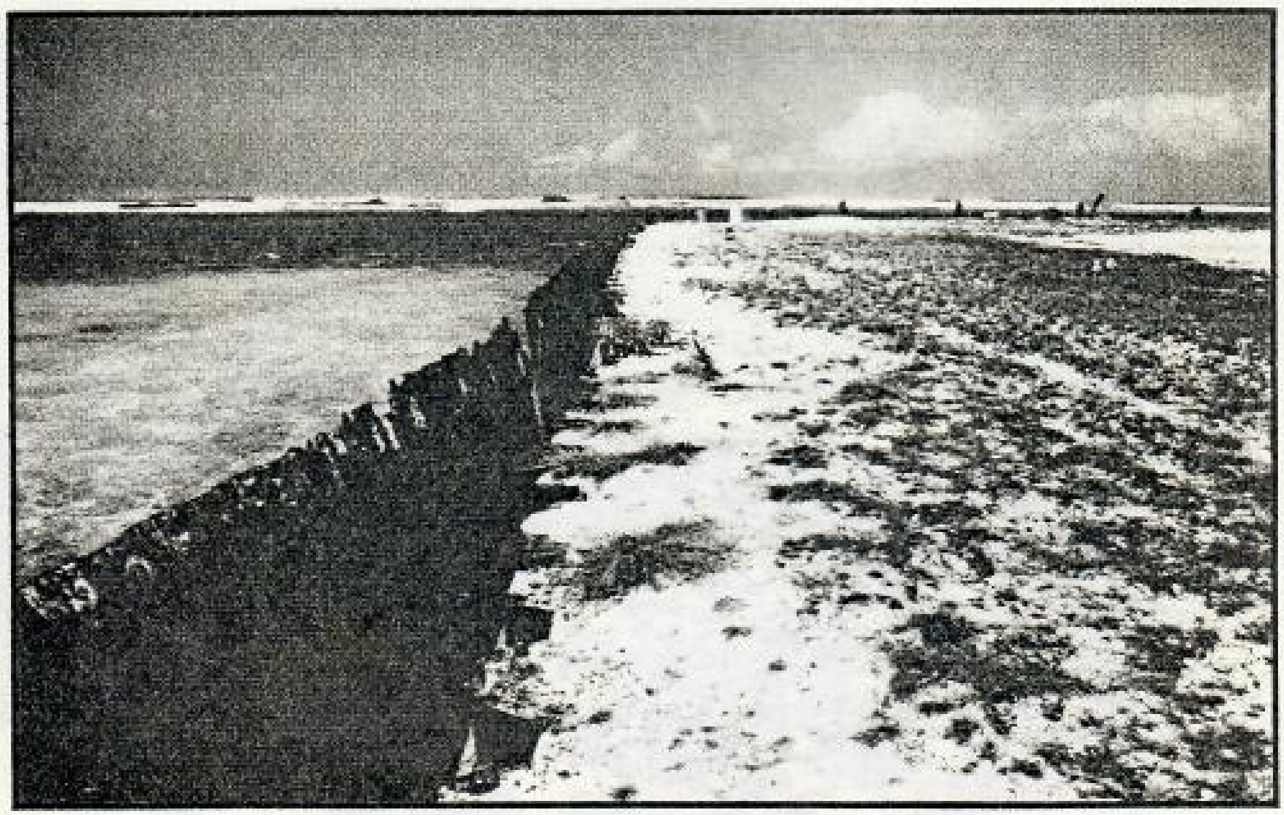


Figure 11. Tern Island - western end of island.

EVALUATION OF THE NEPA REQUIREMENT

The National Environmental Policy Act of 1969 (42U.S.C. 4321-4347), or NEPA as it is more frequently called, was a landmark piece of legislation. One author referred to this legislation as "the most comprehensive, the best known, the most written about, and surely the most litigated federal environmental statute ever enacted (Ref. 72). NEPA requires all Federal agencies to prepare an environmental impact statement (EIS) for "every recommendation or report on proposals for legislation or other major Federal actions, significantly affecting the quality of the human environment.." (emphasis added). Several states, including Hawaii, have subsequently followed suit with passage of similar laws that apply to actions of State and other agencies or individuals.

Much of the litigation concerning NEPA since its passage relates to the determination of whether or not an EIS is needed for particular proposed actions. The answer has usually depended upon whether the action is "major", whether it is "federal" and whether it will "significantly" affect the quality of the "human" environment.(Ref. 72). Council on Environmental Quality guidelines, first published in the Federal Register on 23 April 1971, provided guidance to Federal agencies in the process of determining their EIS responsibilities. Some of the important guidelines and their potential relationship to the Tern Island study are as follows:

(1) "actions" - Included among several different types of "actions" to be reviewed for possible EIS requirements were "projects and continuing activities; directly undertaken by Federal agencies;...involving a Federal lease, permit, license, certificate or other entitlement for use." In this vein, an overt action at Tern Island by FWS (i.e. establishment of

research facility), or granting of a permit to another agency (i.e. fishing station under refuge special use permit) would fall under this requirement. A possible argument could be made that selection of a management alternative for Tern Island would be adequately covered by the FWS' programmatic EIS for National Wildlife Refuge System (Ref. 79). Although there are no clear guidelines for determining which refuge management actions do fall under this EIS, it should be noted that at least one court decision (Sierra Club vs. Morton) determined that annual budget proposals for the refuge system would require a separate EIS, on the grounds that the programmatic statement was directed at the general long-range goals of the system rather than the specific issues involved in annual budget planning(Ref. 72).

An additional argument could be made that abandonment of the Tern Island station by the Coast Guard, and a decision to do nothing to preserve the facility, would not be considered an overt "action" by the FWS, and therefore would not require FWS to prepare an EIS. This argument would be based on the fact that the Navy took over Tern Island during the war without permission of the Dept. of the Interior and subsequently granted permission for use to the Coast Guard, even though it had no legal authority to grant that permission. The 1967 Cooperative Agreement between the FWS and Coast Guard for continuing use of Tern Island was an attempt to put the ongoing occupation of the island in its proper legal perspective. The Coast Guard has, in fact, prepared an environmental assessment and "negative declaration" for disestablishment of the LORAN station at FFS (Ref. 97). It was concluded that the action (disestablishment) is not a major Federal action which will significantly affect the quality of the human environment. Our discussion of the potential adverse impacts on wildlife and other resources that may result from the lack of enforcement presence in FFS provides a basis to seriously question this conclusion. However, it should be noted that this conclusion was reached on the basis of information given the Coast Guard by the FWS that the latter intended to maintain a research station at the site, so the conclusion that Coast Guard disestablishment of the station would not create significant adverse impacts is at least partially understandable. It seems reasonable to conclude that whatever action (including abandonment) that the FWS takes upon disestablishment of the Coast Guard station will be considered an "action" as described in the CEQ guidelines.

(2) "Federal" - If one accepts the argument that management decision and implementation of a management option for Tern Island is an "action" covered by NEPA, then it is also apparent that it directly involves a Federal agency. By the same argument, granting a special use permit for a State agency or private organization to establish a facility would also be considered a "federal action".

(3) "human environment" - Early court cases involving NEPA provided firm ground for concluding that Congress intended the reference to "human environment" to be considered quite broadly. In one particular case (Natural Resources Council vs. Grant) the court stated: "Any action that substantially affects, beneficially or detrimentally, the depth or course of streams, plant life, wildlife habitats, fish and wildlife, and the soil and air 'significantly affects the quality of the human environment'" (Ref. 72). Other court decisions have spoken to the "existence value" of wilderness and wildlife, independent of man's actual use of these resources.

(4) "major", "significantly" - Many court cases have addressed the definition of these terms and their applicability to the EIS decision (Ref. 72). Several criteria for assessing whether or not an action is "major" or whether it "significantly" affects the environment have been considered, but principal guidance comes directly from the original CEQ guidelines. Actions requiring

an EIS include, among others, (a) that "which is likely to be highly controversial", (b) actions which "may be localized in their impact but hav e the potential to significantly affect the environment", (c) actions for which "it is reasonable to anticipate a cumulatively significant impact on the environment", (d) actions which "have beneficial and detrimental effects, even if, on balance, the agency believes that the effect will be beneficial." These CEQ guidelines also indicated that "significant adverse effects on the quality of the human environment include both those that directly affect human beings and those that indirectly affect human beings through adverse effects on the environment."

It is our conclusion from interpretation of these guidelines and pertinent court decisions that the Tern Island management decision clearly meets the relevant criteria justifying preparation of an EIS. Controversiality of the decision is perhaps the most overwhelming determinant, as evidenced by the appended interview summaries. The question of whether or not a thorough assessment of the abandonment alternative should be the responsibility of the Coast Guard or FWS can be argued legitimately. However, it is our opinion that to not prepare an EIS for the varied alternatives seriously under consideration for Tern Island would be in conflict with the intent of NEPA, if not clearly in conflict with the letter of the law.

New CEQ guidelines for implementation of the procedural provisions of NEPA have recently been published (43FR 55978-56007, 29 Nov 1978). The new regulations are designed to improve the quality of the impact statements by establishing a clear format, encouraging the use of a scoping process to identify the most significant environmental issues, insuring efficient involvement of the public and by thoroughly evaluating all reasonable alternative actions and means to avoid or minimize adverse impacts. The new regulations also encourage interagency cooperation before and during the EIS preparation process. The interview process in this study has initiated this effort.

It should be noted that considerable concern was expressed during the interview process that a long-range management decision for Tern Island may be premature at this time, in view of the insufficiency of relevant data and the effect that such a decision may have on the outcome of other issues, or vice versa. The most pertinent other issues include the State-Federal refuge boundary dispute and the potential future designation of critical habitat for the Hawaiian monk seal or green turtle. In addition, the ongoing Triparty Cooperative study is not scheduled for completion until 1981. The purpose of the study is to assess the abundance and distribution of potentially harvestable marine resources and to evaluate the potential compatability of resource harvest and wildlife conservation. The argument has been made repeatedly that implementation of a long range management plan for Tern Island, before the end of the study, would be based on insufficient data and may preclude selection of other options if warranted by results of the study, or subsequent additional research.

In view of the information presented here, it would seem to be the most reasonable and publicly acceptable course of action for the FWS to implement an interim alternative for Tern Island in the immediate future that would not preclude a subsequent change in management objectives at a later date. This would be in keeping with NEPA regulations (Part 1506, 40 CFR), which states that "no action shall be taken which would... limit the choice of reasonable alternatives" during the preparation of an EIS. It may also be justified to hold off final completion of the EIS and implementation of a long-range option until the boundary dispute is settled and until decisions are made regarding critical habitat for the monk seal and turtle. In the meantime, cooperative effort between all agencies involved, with FWS as a lead agency, should be directed towards preparation of a comprehensive EIS.

REPORT FORMAT

The contract for this project included a format for report organization. At the recommendation of MANTA, the Project Officer (Mr. J. Brent Giezentanner, Refuge Manager, HINWR) agreed to a change in format that would more closely approximate established guidelines for preparation of environmental impact statements and allow the opportunity to present considerable background material relevant to this project. Although a formal decision has not yet been made regarding preparation of an EIS, the format of this report should facilitate an objective evaluation of management alternatives and extraction of pertinent data for further use.

This section of the report is followed by a discussion of study methodology. The bulk of the report is devoted to a discussion of various management options, the affected environment and the anticipated environmental consequences associated with implementation of various options. The discussion of management options will treat several potential scenarios in detail. An attempt is made to divide each option into its component actions, to facilitate assessment of specific impacting actions and to indicate which actions the different management alternatives have in common. This treatment will also permit decisions regarding mitigation of impacts through elimination or modification of specific actions.

The list of potential management options in the contract scope of work included reference to both the type of action (i.e., fishing station, research station, abandonment, etc.) and the agency that may or may not be responsible for the action (i.e., FWS, NMFS, DLNR, etc.). We chose to separate the agency management alternatives from the discussion of specific options. The options are described on the basis of the specific actions that would occur, and the types of impacts that these actions may or may not have on the natural and human environment. To a large degree, the agency which actually implements the described option is irrelevant to the impacts of the component actions. What <u>is</u> relevant is whether or not it is feasible for a particular agency to implement any one or all of the described management options. Feasibility may be a matter of economics, staff expertise and availability, jurisdictional authority and resource management policy. These various interacting considerations will be discussed in a section of the report focusing on various agency management alternatives.

The discussion of the affected environment was not actually called for in the scope of work for this study. However, the reader must be aware of the existing environmental conditions, and the anticipated conditions without the project, if he is to fully understand the discussion of environmental impacts. In this report, 15 environmental categories are defined and described briefly as they relate to Tern Island. If an EIS is prepared at a later date, a more thorough treatment of the affected environment would be appropriate, and should include data now being gathered in the Tripartite Cooperative study. Included in the category list are the following:

Hydrography/Oceanography
Geology
Climate
Hydrology & Water Supply
Water Quality
Air Quality
Noise Quality
Aquatic Biota
Cetaceans
Terrestrial Biota
Threatened & Endangered Species
Archeological/Historical
Aesthetics

In a minor deviation from CEQ guidelines, the discussion of the affected environment and environmental consequences are incorporated together under each of the environmental categories listed above. In each category, the extent of detail in the discussion of the affected environment varies with the anticipated significance of project impacts and with the current availability of pertinent data. Ongoing research in the NWHI is directed towards improving the baseline description of the area, particularly with respect to marine and terrestrial wildlife resources. For this reason, the need for additional data is indicated where relevant. Many weaknesses in our ability to predict impacts on various actions on wildlife resources are also identified.

Final sections of the report include a discussion of the relationship between different management options, including the feasibility of implementing more than one option simultaneously. This discussion is of particular relevance to long term management objectives for Tern Island, in view of the variety of suggestions which have been made. This section of the report is followed by a brief discussion of pertinent safety considerations. Section 11 includes an overview of pertinent legal considerations that must be taken into account in evaluating both the impacts and the feasibility of various management options. A bibliography of pertinent reference material concludes the report. It is virtually certain that other documents of indirect relevance to this study, together with others of which we are unaware, could have been included here. Our intent, however, was to be thorough, yet not exhaustive.

Appended to the report are the interview summaries, as required by the scope of work. Additional reports for persons not on the original mandatory contact list are included as well.

STUDY METHODOLOGY

MANTA Corporation submitted a study proposal for this contract on 2 March 1979. This proposal contained an overview of the methodology that would be employed by the MANTA team if selected to perform the work. After notification of selection, work was scheduled to begin on 15 March 1979. The study team organized for this project and their individual responsibilities, were as follows:

Dr. Edward Shallenberger (President, MANTA Corporation)
Project Administration and Interviews/Commercial Fishing and Marine Mammal Component

Ms. Judith Houtman - Secretary/Interview Reporting

Mr. Greg Vaughn - Graphics Specialist

Subconsultants:

Dr. Robert Shallenberger - Report Organization/Terrestrial Ecology and other components not prepared by other investigators

Mr. William Eads - Interviews/Legal and Socioeconomic Research

Mr. Robert Schmitt - Legal Component

Dr. Ron Nolan - Aquatic Biology

Mr. George Balazs - Marine Turtle Biology

The project was initiated by a field trip to Tern Island on 15 March 1979. MANTA was represented on this trip by E. Shallenberger, R. Shallenberger, and R. Nolan. Although Mr. Balazs did not participate on this trip, he has made 22 trips to French Frigate Shoals since June, 1973, each trip lasting five days or longer. During the field trip, pertinent data were gathered during marine and terrestrial surveys and during discussion with Coast Guard personnel on the island.

The data-gathering phase of the project in Honolulu began with scheduling of interviews with those persons included on a mandatory contact list attached to the project contract. The original list of 41 persons or organizations was expanded subsequently to 45 by letter request from

FWS. Additional contacts were made with other knowledgeable persons, as were repeat interviews or phone conversations with some persons on the mandatory contact list. Interview summaries are appended to this report.

Each of those persons on the mandatory contact list was provided explanatory information regarding the contract and the basic management alternatives under consideration, both in a letter sent by FWS and in an informational document sent by MANTA. In addition, a standardized format for interviews was followed to insure coverage of pertinent material and to allow extraction and comparison of information. Each interview began with a brief review of the study purpose, and the methods by which pertinent information would be gathered and incorporated into the report. Interviewees were also asked to submit additional written information or other documentation if they wished to contribute pertinent data after the interviews were concluded. In most interviews, each of the basic management options was discussed, although the focus of any particular interview depended considerably upon the specific expertise and experience of the interviewee. Information was gathered to help develop a detailed picture of the actual management options that could be implemented and to assess the anticipated environmental impacts of each. Effort was made to differentiate between fact and opinion where possible, but it must be re-emphasized that in the grey area of impact assessment there often is no fine line between the two.

After completion of the interview, a meeting summary was prepared and returned to the people present at the interview for review, clarification or addition of pertinent information. This approach was considered to be more appropriate than preparation of recorded interview transcripts, as it allowed those involved to speak freely, yet have the opportunity to review the report of the meeting for accuracy or clarification. Persons involved in the interviews were also asked to note whether or not their comments represented agency or organization positions.

The interview process, although critical to the data gathering phase of the study, was not as successful as anticipated. Because of the need to incorporate data into the draft report, the first month of the study period was originally allotted for interview. This proved to be too short in many respects. Some contacts wished more time to review the subject before meeting with MANTA. Many of those representing agencies or organizations were unable to provide statements that reflected a consensus or agency opinion because of the insufficient time available to meet and review the subject with others in their organization. Simple lack of time to review information and comment was a complicating factor, particularly for those State and Federal legislators involved in ongoing sessions. Perhaps the most distressing, and unfortunate, complication in the interview process was the refusal of some persons to speak with MANTA, at least in part because they felt that participation in the process would imply recognition of FWS jurisdiction over Tern Island. We had hoped that the overriding need to gather pertinent information, regardless of jurisdiction, would stimulate a willingness to participate in the project.

The interview process was also complicated by the fact that the specifics of various management options were very vague at the beginning and evolved throughout the project as each person added input. For this reason, those persons interviewed at the beginning of the project did not have the same opportunity as those at the end to react to the details of the various management options. Finally, it should be noted that the list of interviewees, although covering a wide range of expertise, could easily have been expanded given sufficient time. In view of the long range implications of a Tern Island management decision, the issue takes on national and even international significance.

The data gathering phase of this project also involved review of pertinent published and unpublished materials. This search began with a bibliography appended to the study contract. It continued with a review of refuge files, scientific journals, newspaper reports and results of unpublished studies. The primary difficulty in this phase of the study was not finding the information, but in deciding when and where to stop. One bibliographic reference alone, focusing only on the Northwestern Hawaiian Islands, contains nearly 1300 published sources of material (Ref. 29). Another bibliography of published data focusing only on northwest island seabird resources and only partially overlapping with Ref. 29 , contains more than 750 citations (Ref. 154). Although only a small percentage of these references pertain directly to the Tern Island management decision, virtually all of these and many more are interrelated with the bigger question regarding the compatibility of marine resource exploitation and wildlife conservation in the northwest islands. For this reason, our reference list of pertinent materials is by no means exhaustive, but it does focus on the most pertinent data.

Given the short period allowed for completion of the draft report (60 days), the assessment process must be considered somewhat superficial. Following the Council of Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (43 FR 55978-56007, Nov. 29, 1978), our efforts to date should be considered part of the scoping process defined in section 1501.7 of that regulation. The intent of the scoping effort is to 1) invite participation of other interested persons (initiated here through the interview process), 2) determine the scope and the significant issues that should be analyzed in depth, and 3) identify and eliminate the issues that are insignificant or covered adequately elsewhere. We have taken the process a major step further in the intitial evaluation of project impacts, based upon pertinent data available at this time.

ALTERNATIVES CONSIDERED

INTRODUCTION

Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act were published in the Federal Register on 29 November 1978 (40 CFR Parts 1500-1508). In the revised format for preparation of environmental impact statements, considerable attention was directed towards description of the alternatives under consideration by the agency preparing the EIS. The agency is directed to "rigorously explore and objectively evaluate all reasonable alternatives", including reasonable alternatives not within the jurisdiction of the lead agency. The no-action alternative should also be included. The regulation indicates that the agency should indicate its preferred alternative in the draft and final EIS.

Although this assessment is not intended to fulfill agency responsibility under NEPA, an attempt is made to follow the appropriate guidelines as closely as possible to facilitate incorporation of pertinent information into a DEIS and FEIS if such a course of action is taken. To that extent, a wide array of management alternatives for Tern Island are presented in this section of the assessment and evaluated in detail in subsequent sections.

MANTA was faced with a somewhat atypical situation in impact evaluation in that the array of feasible management alternatives for Tern Island are not easily defined. Review of the appended interview summaries will substantiate the fact that the details and feasibility of potential management alternatives are subject to much debate. The alternatives included in the scope of work for this contract included the following:

1. Conversion of the existing facilities, or a portion of the existing facilities, to a research station administered and operated by the FWS, which would support general wildlife, threatened and endangered species, coral reef ecology and natural area ecosystem research.
2. A similar station to 1. above operated by another agency (NMFS, University of Hawaii, State of Hawaii, etc.) or jointly with FWS.
3. Conversion of existing facilities or addition to existing facilities to be used as a commercial fishery support station.
4. Modification or abandonment of existing facilities to achieve maximum indigenous wildlife use.
5. Other options that come to light as a result of study and evaluation.

An informational document was prepared by MANTA Corporation and sent to mandatory interview contacts on this project. In this document, an additional alternative was added to the list for consideration prior to the interviews: joint research station/commercial fisheries support station. The standardized format, followed on most of the interviews, included the six alternatives described above as a focusing point for the discussion.

While conducting the interviews and gathering pertinent source materials, it quickly became apparent that the original array of alternatives were somewhat confining in scope, and, at the same time, indefinite in detail. The primary differences of opinion expressed in the interviews involved the specific details and magnitude of the research and fishery options, and the question of agency management. As the details of the options evolved in discussion and literature survey, it also became apparent that the type and severity of environmental impacts associated with an option related more to the individual component actions involved in implementing the option than the overall plan itself. Research and fishery options shared many component actions, and to this extent, the resulting environmental impacts often have much in common when options are compared. The question of agency management dropped out as a separate question in itself and is so treated in Section 6 of this report.

The final array of alternatives to be discussed here and evaluated elsewhere in this report focuses on several levels of intensity of research and fishery stations. In view of the significantly different impacts associated with different types of fishing (and consequently different types of support on Tern Island), eight categories of fishing support facility are evaluated in this report. These categories follow the general pattern outlined in the Interim Report to the 10th State Legislature (Ref. 63). It is recognized that the categories of fishery support considered are, to some degree, hypothetical in view of the inadequate stock assessment data available. It should also be noted that support facilities on Tern Island for the various fishery options are not necessarily mutually exclusive, although limitations on space and other constraints may determine the extent to which various options are compatible with each other or with research options.

The research station options are categorized here largely by size or level of intensity. Various types of research are considered and it is certain that other scientific uses of Tern Island facilities are possible that were not considered in this report. One option relating to both fishing and research support is categorized in this report as an outpost facility. Serving primarily as a point of contact for emergency evacuation, this option could provide limited support for either or both fishery or research uses of the French Frigate Shoals area. The function of an outpost facility could also be absorbed by all the other alternatives with the exception of the no-action alternative. Recreational/educational is discussed here as a final category of human use at Tern Island, but it is not seriously considered as an independent management alternative. Rather it is treated as a potential corollary or compatible use with other options.

Table 1 includes a presentation of the various component actions of the management alternatives that may or may not impact the environment. A discussion of the component actions follows table 1. In this table an attempt is made to assign a level of intensity to each action under the various alternatives. The assignment of this intensity number does not necessarily imply a magnitude or significance of impact. However, an action is likely to cause adverse environmental impacts (i.e. small boat traffic in inshore waters) would be considered most significant for a management option in which the action occurs frequently or with great intensity (i.e. skiff fishery).

<u>Abandonment</u>

Abandonment of the island, for purposes of discussion, is considered here to be the no-action alternative. In the most extreme case, this would involve total disregard for the island and its facilities once the

Coast Guard (CG) leaves. Anything remaining on the island would be left to rot or rust, or would be subject to future independent illegal salvage by trespassers in the refuge. A more realistic abandonment alternative could include removal of salvageable equipment and "mothballing" of facilities and remaining equipment for potential future use. A final version of the alternative would include leveling and removal of all buildings, foundations, fuel tanks, towers, equipment and other facilities. An extension of the total removal option could include bulldozing of the runway or other modification of the ground surface to encourage wildlife use.

The CG prepared an environmental assessment and negative declaration for disestablishment of the Tern Island LORAN station in March, 1979 (Ref. 97). In order to evaluate the most likely course that the abandonment alternative may take, it is valuable to review the current negotiated plans of the CG, as outlined in the EIA and in letters of agreement between the CG and FWS.

The details regarding final disposition of equipment and facilities on Tern Island when the CG leaves have been a subject of negotiation between the CG and FWS since official notification of station disestablishment was received in 1978. As of 1 May 1979, there still remain some unsettled questions regarding specific action the CG will take upon leaving. The most current plan calls for destruction of two storage buildings and a beach clubhouse, removal of the LORAN transmitting tower and two other antennae, removal of some garbage and waste material and incineration of burnable material. Scrap metal will be buried on site. All rolling stock will be left on the island and buildings will be left in a habitable condition. The FWS has requested that the five diesel fuel tanks be steam cleaned and converted for water storage use, but no agreement to accomplish this task has been negotiated. Current plans are to leave the generator facilities on the island. The CG EIA for station disestablishment (Ref. 97) indicates that all unused portions of the island will be cleaned up and restored to a condition suitable for use as bird habitat. Finally, current plans call for the CG to remove its channel and harbor bouys when leaving the island, although it has been suggested that an arrangement could be made by FWS to have the CG install FWS buoys at the same time and to service the FWS buoys during annual visits by buoytender to the site. In a recent (12 April 1979) letter from the Acting Area Administrator of FWS to the CG, FWS requested that additional radio equipment (certain antennaes, transmitters, receivers and radio beacon) be left on the island to permit continued communication and search and rescue capability.

Outpost Facility

This alternative would involve a limited use facility. Emphasis would be placed on maintenance of the physical plant in a condition that would allow restoration to support people up to the existing capacity (20 people) at a later date. Work would consist of maintaining the airstrip in a condition capable of handling light twin engine aircraft (filling, grading and compacting as necessary), maintaining the existing buildings and their associated systems (painting, rust preventing, plumbing, etc.), maintaining the generators and aids to navigation(radio beacons, buoys, etc.), maintaining communication and support of visiting refuge personnel or scientists. Periodic intense activity would be required to repair damage from storms and wave action and to maintain seawalls. The actual number of people required to run the outpost station is the subject of some debate, but it is clear that at least two people would be necessary for safety consideration.

The primary function of the station would be to provide emergency evacuation capability, but the facility could also provide limited research or fishing support. The managing agency would not encourage research scientists to use the facility, but housing and some logistical support could be provided on an intermittent basis. Only very high priority research, that could not be accomplished elsewhere, would be permitted under this arrangement. Alternative power sources (wind, solar, small generator) would be employed. The low intensity of use would probably permit use of a chemical alternative to the existing contained sewage treatment plant. The outpost station could provide fuel and other limited supplies for support of a fishery that would not require on-island housing. Fuel support of fishery activities would necessitate more frequent resupply of the station fuel tanks than would an outpost station supporting only limited research.

<u>Mid-Level Research Facility</u>

This facility would be equipped to support a greater level and frequency of research activities than would the outpost facility. Support equipment (water supply, sewage treatment plant, galley, housing, radio communication, etc.) would be maintained in operating condition, and would be readily adaptable to a highly variable number of refuge personnel or scientists on the island at any one time. Under this option, an average number of people on the island during prime research months (April-September) would run between 8-12, including a permanent maintenance staff. Some facilities would be out of operation, but maintained, during winter months. No additional construction would be necessary, as the primary focus would be on field research on Tern Island and elsewhere in FFS. Support equipment for field work would include small boats (minimum 2), motors, radios, diving gear, repair facilities, etc. Transportation to the island would be by chartered light twin engine aircraft on an intermittent basis, averaging 2-3 trips per month during peak research periods. Travel could also be arranged on appropriate research vessels visiting the station.

Full Level Research Station

The distinction between a mid-level and full level research station is unclear, although the latter option would necessitate maintenance of maximum existing support capability and possibly expansion to accomodate a greater number of people on a short term basis. The principal limiting factor on the island at this time is water supply. A greater amount of water could be accomodated by increasing water storage capability (i.e. use of existing fuel storage tanks), increasing surface collection capability or by improved distillation or desalinization equipment. However, for the purposes of evaluation in this report, full level will be considered to be equal to the existing facility (20 persons).

This alternative would require a larger permanent staff to provide food, housing and logistical support for field research. Additional construction of research facilities (holding tanks, wet labs, etc.) may be required depending upon the type of research conducted. It is anticipated that weekly supply and transportation flights by light twin engine aircraft would be required. The frequency of this activity would necessitate storage of some aviation gas on the island. Intensive field research in FFS would require several small boats, necessitating dock facilities, repair equipment and space, launching equipment or ramp, improved radio communication and logistics. Conceivably this alternative may also involve establishment of outpost facilities on one or more other islets within FFS. Some fuel storage capability could be incorporated into the plan to allow support of larger research vessels in the FFS area.

Other Recreation/Education Support Facilities

The possibility of visitor use of Tern Island, other than for fishing or research activities, proved to be a controversial topic in the interview phase of this study. Current FWS refuge policy for the HINWR does not encourage non-scientific use of the refuge, but there is a history of limited FWS cooperation in the production of educational materials (articles, movies, etc.) by independent individuals or organizations. Policy regarding visitation to refuge lands and waters, including Tern Island, for other recreational or educational purposes, has been applied inconsistently. The overriding concern of the FWS in this regard has always been the potential disturbance of refuge wildlife and other adverse impact of human visitation to the refuge islands. One alternative to accomodate increasing demand to visit refuge areas for educational/ recreational purposes was proposed in the 1970 Master Plan for the HINWR. This plan included development of an interpretative facility in Honolulu to inform the public about the refuge and to generate support for continued protection.

It was suggested during the interview process that Tern Island could provide a "window on the refuge" for the interested layman. The intent would be to provide one location in the refuge that was accessible, at which the visitor could view most of the area's wildlife on a non-interference basis. The plan would not require visitation to other islands at FFS, but it could involve limited non-consumptive diving in selected areas within the lagoon. Access to FFS would be by light twin engine aircraft or by charter vessel. Accomodations would be necessary on Tern Island, unless aircraft visits were for one day only. The number of people that could be accomodated would depend upon other uses of the island, and the ranking of priorities by the managing agency. It is not anticipated that any alteration of the existing physical plant would be necessary. Presumably this would be a seasonal use only.

Inshore Fishery Support Facility

Because of the shallow protected water and the nature of the types of fishing possible within FFS (independent of existing regulations), this option is primarily a small boat or skiff fishery. Species sought would include ulua (Caranx, Carangoides), akule (Trachurops), opelu (Decaptarus), moi (Polydoctylus), goat fish (several genera), and possibly lobster and crab. Several methods of fishing would be used, possibly including surround nets, hand lines, kaka lines and traps. Fishing would be within the protected waters of the lagoon and outside the lagoon when weather permitted. The fishermen would be dependent upon Tern Island as a base and consequently would be limited in number by available space.

With a support staff of 4, an additional 8 crews of 2 people each could be supported. Conceivably other buildings on site could be converted to housing, additional housing constructed or more people crowded into the existing housing. However, unless additional water catchment and storage capability was developed, the number of people would be limited by this parameter.

Unless the skiffs were working in concert with a larger support vessel, refrigerated storage of the catch on the island would be essential. Depending upon the ability of the market to absorb highly fluctuating catches, some freezer capability may be required. The amount of storage capacity would be dependent upon the number of fishermen, their success rate, and the length of storage time necessary. Conceivably the catch rate could run between 100-500 lbs/day/boat. Transportation of the catch would be on chartered aircraft or on other commercial fishing boats in the area. One fishermen already visiting the FFS area indicated that he would consider transporting the catch of others back to Oahu.

Supplies required for a skiff fishery would include food, water, fuel, oil, gas, ice and fishing equipment. All except ice could be transported by fishing vessels or aircraft. Ice production would be required at a rate of at least 300 lbs. per day for each boat. Lobsters or crabs caught by this fishery would have to be kept in holding tanks or processed on island. Frozen squid or aku heads could be used for bait. On-island repair facilities would also be necessary, and the equipment for docking and offloading fish would need to be upgraded. Skiffs would be based at Tern Island and would have to return each day for supplies and to offload their catch. Although the skiffs could be moored near the island or stored onshore during the summer fishing season, the number of days that they could fish in the winter months would be limited by weather. It is very likely that the fishery would be seasonal, with a minimum maintenance staff on island during the off season.

This fishery would require maintenance in operating condition of all existing equipment (generators, sewage treatment, water supply system). In addition, communication between Tern Island and working skiffs would be necessary. A radio beacon would need to be in regular operation to facilitate navigation by aircraft. In order to accomodate the anticipated catch economically, the runway would need to be maintained in a condition capable of handling large aircraft (i.e. DC-3). This would necessitate control of nesting birds on portions of the runway. Maintenance of the runway surface, dock facilities, seawalls and all operating equipment would be required.

Trap Fishery Support Station

For the purposes of discussion, this fishery includes lobster, kona crab, shrimp and fish trapping. This methodology has been used with some success for all these species in the main islands. Preliminary trapping efforts in the Northwestern Hawaiian Islands for shrimp, lobster and crab have been encouraging in some cases. The traps involved in these fisheries differ considerably. Fish traps are usually large rectangular cages, sometimes up to 8 feet long. Lobster traps are smaller with considerably smaller openings. Crab traps are round rings with stretched net across.

Most of the fishing under this alternative would occur in water greater than 15 fathoms. Traps are usually set in a long line across the bottom and left for periods of time. Because of the size of the traps, and the number needed to economically justify the effort, carrying capacity is critical for a commercial operation. Therefore boats of at least 50-60 feet are used. Boats of this size do not regularly fish the Northwestern Hawaiian Islands because of insufficient fuel and and storage capacity. However, storage of fuel at Tern Island would allow these boats to fish traps at FFS as well as other northwestern islands within their fuel range. These boats would be sufficiently self-contained so as to require only fuel and opportunity to offload catch on Tern Island, possibly on a weekly basis.

Lobsters and crabs would have to be processed at Tern Island or kept alive for shipment to Honolulu. In either case, some holding facilities would be necessary. Shrimp would have to be processed soon after capture. A viable fishery would require either onboard processing, a processing plant on Tern Island or a processing facility on a mother ship.

Several factors would interact to determine the number of boats that would be involved in a trap fishery at FFS. Preliminary data suggests that only a very small percentage of the State's trap fishery resources are presently being harvested (Ref.63). Conflicting information indicates that some of these resources, particularly lobster, can easily be depleted when fished heavily within limited geographical areas. Suffice it to say, the viability of a long term sustained yield trap fishery remains to be seen. This fishery would have to be weather permitting, particularly if the boats were dependent upon Tern Island for fuel and offloading of catch. The crab and lobster fishery would possibly also be limited by regulations that prohibit fishing during periods of egg laying (June-August).

Ahi, Bottomfish and Groundfish Fisheries Support Facility

The Hawaii Fisheries Development Plan suggests there is a potentially viable fishery for these resources in the Northwestern Hawaiian Islands (Ref. 63). Presently bottom fish are being caught in the Northwestern Hawaiian Islands by four long range vessels. The most commonly caught species are opakapaka (Pristipomoides filamentosus), onaga (Etelis carbunculus), uku (Aprion virescens), hapuupuu (Epinephelus quernus), kahala (Seriola dumerilii) and uluas (Caranx and Carangoides). According to Ralston (Ref.137), the catches of these species in the main islands have already reached minimum sustained yield, but there remains a considerable resource within the Northwestern Hawaiian Islands. Virtually all of these bottom fish are caught with bottom handlines, some hydraulically or electrically operated. Yellowfin and big-eye tuna are caught in the main islands by long line, trolling or "ika-shibi." The vessels engaged in these fisheries are short and medium-range vessels that are not capable of fishing in the northwestern islands without aid of a fishing station.

Groundfish (armorheads and alfonsins) are not currently exploited by U.S. fishermen but are caught by Soviet and Japanese trawl vessels over seamounts and guyots northwest of Midway Islands. Although not currently fished near FFS, these groundfish have been experimentally captured, and may exist in the area in commercially harvestable quantities. If mid-range vessels could use Tern Island for fuel, offloading catch and as an anchorage in inclement weather, this resource within 200-300 miles of FFS could be effectively exploited. All of the fishing would be outside refuge waters, in 60 fathoms or more. Because of the size of the vessels, it is likely that this would be a seasonal fishery.

Use of a support station at Tern Island for this fishery would require maintenance of the runway for large aircraft, improvement of dock and offloading facilities, refrigerated storage, ice production, equipment repair facilities and mooring capability in the vicinity of the island. No on-island housing would be required except for a permanent maintenance staff, probably numbering less than four.

Aku Fishery Support Station

Aku fishing in Hawaiian waters is a pole and line fishery using live bait to hold skipjack tuna close to the boat. Limited supply of suitable baitfish (principally nehu, Stolephorus purpureus) and high mortality of bait in holding tanks have been the principle factors hindering expansion of the aku industry in Hawaii. Nehu are caught in local waters by surround net, fishing both day and night. Principle nehu fishing areas are Kaneohe Bay, Pearl Harbor and Keehi Lagoon. The local stocks of nehu are not believed to be large enough to sustain a significant expansion of the aku fishery into the Northwestern Hawaiian Islands, even if methods could be developed to reduce mortality in transit (Ref. 63). As an alternative, the State has been pursuing an aquaculture program on the island of Maui, attempting to rear sufficient quantities of alternative bait species (principally topminnows) that suffer significantly less mortality in bait wells. The success and potential yield of this experimental program is still uncertain at this time. There is also an undefined potential for offshore bait supplies within the Northwestern Hawaiian Islands. It is uncertain whether or not Japanese aku boats fishing in the vicinity of these islands are using live bait brought from Japan or offshore bait resources, although these boats are estimated to take approximately 15,000 tons of aku annually in waters adjacent and southward from the Northwestern Hawaiian Islands (Ref. 63). A final alternative for imported bait, transport from California, is considered to be prohibitively expensive due to the lack of suitable shipping connections from southern California, and the shortage of West Coast anchovy during the summer months (Ref.63).

It is possible that the bait-rearing methodology, if proven successful, could be employed at Tern Island to permit exploitation of aku resources in the mid-archipelago. This activity could involve on-island bait tanks, or alternatively, nearshore permanent net facilities. Alternatively, and a subject of considerable recent controversy, is the possibility that existing baitfish stocks within the shallow waters of French Frigate Shoals could be successfully fished. The potential yield of these stocks is unknown, and conflict with refuge management objectives is inevitable.

The amount of movement of aku boats in FFS waters would depend upon resolution of the baitfish problem. If baitfish is brought into the area or caught at sea, there would be no mandatory support requirements for aku boats at Tern Island, other than emergency evacuation or protection from weather in the lagoon, fuel and ice. All fish could be offloaded and catch transported by a mother ship.

Alternatively, fish could be offloaded at Tern Island and shipped by air. The frequency of flights necessary would depend upon the number of boats using the facility, capacity of the aircraft, size of the freezer storage facility and conditions on the Honolulu fish market. There are presently only 14 aku boats in Hawaiian waters, and unless there was an unexpected influx of mainland boats, it is unlikely that many would make the move to exploit this unproven resource. Based on existing bait carrying capability, it is anticipated that each aku boat would visit the Tern Island facility at least once every third day. Each boat would require at least 300 pounds of bait per trip. It is uncertain how much time would be required to catch bait in the FFS lagoon, but catch data from night fishing (average 8 hours) and day fishing (average 3 hours) for local waters may be illustrative (Ref. 167). Most of the bait caught in local waters is caught within 0.5 miles of shore.

No housing would be required on Tern Island other than that necessary for a small (2-4 persons) on-island staff for equipment maintenance and processing of catch. On-island bait rearing facilities would require a permanent staff. Fuel would be required to support the aku boats unless a mother ship satisfied this need. The runway would have to be maintained in its full capacity if air shipment was employed for aku. Ice would be required in quantities that would vary considerably with the number of boats using the facility, and whether or not the vessels employed brine systems that required no ice.

Albacore Fishery Support Station

The use of Tern Island as a support station for albacore boats has been suggested. Under this plan, the boats would use the island only for fueling and offloading of catch. These vessels are long range and largely self sufficient, and would probably have no other need for the island. On-island requirements could include offloading capability, freezer facilities and air shipment. Conceivably, each boat could unload as much as 30-40 tons of fish and require several thousand gallons of fuel, but the visits to the island would be infrequent. Movement of boats within FFS would be restricted to the dredged channel to Tern Island. This would be a summer fishery only.

The viability of an albacore fishery out of FFS is highly questionable. The main stock of North Pacific albacore are believed to migrate back and forth across the Pacific, passing close to Midway Islands (Ref. 63). It is estimated that the potential yield of this fishery to U.S. boats could be as high as 15,000 tons annually. An experimental fishing program involving a single mother ship and up to 20 catcher vessels is now underway at Midway. In view of the as yet unproven viability of the Midway fishery, the questionable availability of albacore in the central portion of the archipelago, and the potential use of a mother ship, it is unlikely that there will be significant pressure among commercial fishing interests to provide support facilities at Tern Island for the albacore fleet in the near future.

Sport Fishery

As early as 1946, when the U.S. Navy offered Tern Island to the Territory on revocable lease, the possibility of recreational sport fishing at Tern Island has been considered. At that time, a "fishing resort" with a remodeled facility and regular flights from Honolulu was suggested. Based on the results of the interviews for this study, sport fishing is still considered a viable alternative use for Tern Island. This fishery would probably involve large reef fish (ulua, tiger sharks) and pelagic species (ono, mahi mahi, and billfishes). The sport fishery would have some unique on-island requirements. Because of the tourists involved, living quarters might have to be somewhat more comfortable than would be necessary for fishermen or researchers. The living quarters may have to be separate from the space used for caretakers, fishermen or scientists. Sport fishing would require frequent flights in and out of Tern Island, but light twin engine aircraft would suffice.

The vessels used for sport fishing would have to be small enough so that they could be loaded onto a larger vessel or large enough to make the trip under their own power. This requirement would probably eliminate many of the vessels currently sport fishing in local waters. Like other boats, these vessels would require fuel and other supplies. This fishery would require freezer and ice facilities on Tern Island. Demand for fuel, ice and freezer space would vary considerably, depending upon the number of boats using the island. The fishery would be seasonal. It would be necessary to store boats on island or return to Honolulu during winter months.

Aquarium Fishery Support Station

The use of Tern Island as a base of operations for an aquarium fishery has also been suggested. Such a fishery would require small boats, holding tanks, SCUBA compressor and diving gear, housing and food for collectors. Frequent flights with light twin engine cargo aircraft would also be necessary. Boat and engine maintenance facilities would be required, as would fuel and/or gas supplies.

Virtually all fishing would occur within existing refuge boundaries, using traps, nets and chemicals (i.e. quinaldine). There would be considerable boat movement within shallow waters of FFS. The fishery would be weather-permitting, probably requiring boat storage on island during winter months. Safety considerations would include potential hazards of diving (including need for decompression), sharks and the potential failure of motors away from Tern Island.

Precious Coral Support Facility

The only fishery for precious coral in the U.S. Fishery conservations Zone is in the Hawaiian Islands. Two species (pink and gold) make up the bulk of the catch. Virtually all of the local harvest has occurred in the identified Makapuu Bed. Five other precious coral beds have been identified in the Hawaiian archipelago, three of which are in the Northwestern Hawaiian Islands. WesPac Bed is located between Nihoa and Necker Islands; Brooks Bank is located less than 50 miles from French Frigate Shoals; 180 Fathom Bank is north of Kure Atoll. There are likely to be many other undiscovered beds, particularly in the Northwestern Hawaiian Islands, where little exploration has occurred (Ref170). Of the five unharvested areas, the three in the Northwestern Hawaiian Islands are believed to hold the most promise.

A recently prepared management plan for precious corals in the U.S. Fishery Conservation Zone classified the five identified, but unfished, coral beds as "Conditional Beds" (Ref. 170). The plan recommends harvest quotas for each, with the exception of the WesPac Bed. The latter site would be closed to precious coral fishing to provide a reserve for possible reproductive replenishment of other beds and as a baseline for monitoring effects of harvest on coral populations. Both non-selective harvesting (dredging with tangle nets) and selective harvesting (presently by submersible) would be permitted by both domestic and foreign vessels in the Conditional Beds.

The only domestic coral harvest operation employs a submersible, towing barge and 70 foot support vessel. Foreign dredge haulers range between 40-100 feet and deploy between 4 to 8 dredges simultaneously (Ref. 170). It is uncertain at this time whether or not support facilities at Tern Island would be justified for expansion of domestic harvest of precious coral in the Northwestern Hawaiian Islands. Proximity of the island to the Brooks Bank would conceivably facilitate exploitation of this source and search for other as yet unidentified coral resources. Fuel and water would be the most critical necessities from a land base support station. No air shipment of catch would be necessary. No boat movement outside the dredged access channel would be necessary within refuge waters.

TABLE 1. POTENTIALLY IMPACTING ACTIONS

BOAT-RELATED ACTIONS	1 ABANDON ISLAND	2 OUTPOST FACILITY	3 MID-LEVEL RESEARCH	4 FULL-LEVL RES.	5 RECREAT/ EDUCATION	6 INSHORE FISH.	7 TRAP FISH.	8 AHI, ET AL. FISH.	9 AKU FISH.	10 ALBACORE FISH.	11 SPORT FISH.	12 AQUARIUM FISH.	13 PRECIOUS CORAL
1 BOAT FUEL STOR.	0	0-2	0-3	1-3	0-1	1-3	2-4	4-5	4-6	4-5	2-3	1-3	1-3
2 WATER STORAGE	0	0-1	0-2	0-3	0-1	0-2	1-3	1-3	1-3	1-2	1-2	0-1	1-2
3 GAS STOR./TRANS	0	1	1-2	1-2	2	1-2	1	1	1	1-2	1-2	1-2	1
4 SPARES/SUPPLIES	0	1	1-2	1-2	1-2	2	1	1	1	1-2	2	2	1
5 REPAIR SHOP	0	1	2	2	2	2	1-2	1	1	1	1	1-2	1
6 FROZEN FISH STOR.	0	1	0	1	0	2-3	3-5	4-5	4-6	4-5	2	0	0
7 REFRIG FISH STOR.	0	0	0	1	0	2-3	0	2-3	2-3	0	2-3	0	0
8 LIVE CATCH STOR.	0	0	1-2	1-4	0-1	0	2-5	0	0	0	0-1	1-5	0
9 BAIT REAR./STOR(LND)	0	0	0	0	0	0	0	0-1	4-5	0	0-1	0	0
10 BAIT REAR./STOR(LAG)	0	0	0	0	0	0	0	0-1	4-5	0	0-1	0	0
11 ICE PLANT	0	1	1-2	1-2	1	2-5	2-3	3-5	3-5	0	1-3	0	0
12 OFFLOAD EQUIP.	0	1	2-3	3-6	2-4	2-3	2-3	2-4	2-4	2	2-4	1	2-4
13 SKIFF DOCK FAC.	0	1	2	2	2	2-3	2	2	2	1	3	2-3	1
14 MED.RANGE VES.DOCK	0	0	2	4	0	0	5	5	5	5	5	0	5
15 LONGRANGE VES. DOCK	0	0	2	4	0	0	5	5	5	5	0	0	5
16 SKIFF MOORAGE	0	1-2	2-3	2-5	2-3	5	2-3	1-2	1-2	1-2	2-3	2-3	1-2
17 MED.RANGE VES.MOOR	0	1-2	3-5	2-4	3-5	0	3-5	5	5	3-5	4-5	2-3	5
18 LONGRANGE VES.MOOR	0	1-2	3-5	2-4	3-5	0	3-5	5	5	5	3-4	2-3	5
19 ONLAND SKIFF STOR.	0	0-2	1-3	1-4	1-3	1-4	1-3	0-1	0-1	0	0-2	1-3	0
20 FUEL SUP. TO ISLND.	0	1	2-4	5	2-5	3-4	3-5	4-5	4-5	4-5	3-5	2-4	3-5
21 SHIP/SHORE COMMUN.	0	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
22 WASTE OIL DISPOSAL	0-4	1	2	3-6	2-3	2-3	2-4	2-5	2-5	2-5	2-5	2-5	2-5
23 SKIFF MOVEMENT(TERN)	0	1-2	2-5	3-5	2-4	5	1-2	1-2	1-2	1-2	1-2	3-6	1-2
24 M[illegible] VES. MOVE[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	0	[illegible]	4	[illegible]
25 LONGRANGE VES. MOVE.	0-4	1	1-2	1-2	1-2	0	1-3	1-2	1-2	1	1-3	0	1-2
26 BOAT SEWAGE DISP.	0-4	0	1-2	1-2	1-2	0	3	2-3	2-3	1	2-3	0	1-2

TABLE 1: POTENTIALLY IMPACTING ACTIONS (CONT.)

		1 ABANDON ISLAND	2 OUTPOST FACILITY	3 MID-LEVEL RESEARCH	4 FULL-LEVL RESEARCH	5 RECREAT/ EDUCATION	6 INSHORE FISH.	7 TRAP FISH.	8 AHI, ET AL. FISH.	9 AKU FISH.	10 ALBACORE FISH.	11 SPORT FISH.	12 AQUARIUM FISH.	13 PRECIOUS CORAL
27	BILGE DISCHARGE	0-4	0	1	1-2	1-2	0	1-3	1-3	1-3	1	1-3	0	1-2
28	ON-LAND VEHICLE	0	1	2	2	2-3	2-3	3-4	3-4	3-4	3	2-3	2-3	1-3
29	DREDGING	0	0	0	0	0	0	0	0-3	0-3	0-3	0-3	0	0-3
30	CHANNEL MARKERS	0	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
31	MOTHER SHIP/BARGE	0	0	0	0	0	0	0-3	0-3	0-3	0-3	0-3	0-3	0-3
	AIRCRAFT RELATED ACTIONS													
32	LIGHT TWIN	0	1	2-3	5	3-5	1	1	1	1	1	3-5	2-5	1
33	DC-3	0	1	1-3	2-3	1-3	3	3	3-5	3-5	0	1-2	0	1
34	C-130	0	1	1	1-3	1	1	1	1	1	1	1	1	1
35	RUNWY MAINTEN.	0	2	3	3	3	5	5	5	5	1	4	2	1
36	BIRD CONTROL	0	2	3	3	3	5	5	5	5	2	3	2	1
37	AVGAS STORAGE	0	0	2	3	3	1	1	1	1-3	0	2	2	1
38	AIRCRAFT STOR.	0	0	2	2	1	0	0	0	1-3	0	2	0	0
	OTHER ACTIONS ON TERN IS													
39	ROOM/BOARD	0	1	3	5	1-4	3-5	1-2	1	1	0	3	3	1
40	RESEARCH LAB	0	1	3	5	2	1	1	1	1	0	1	1	1
41	RECREATION	0	1	4	5	5	5	1-2	1	1	1	3	3	1
42	EDUCATIONAL USE	0	2	3	5	5	1	1	0	0	0	1	1	0
43	ON-ISLAND RESEARCH	0	1	2	2-4	2-3	0	0	0	0	0	0	0	0
44	FUEL DEMAND	0	2	3-4	5	2	2	2-4	3-5	3-5	3	3-5	2-3	2
45	WATER STORAGE	0	2	3-4	5	2-4	2-3	4	4	4	1-4	4	4	4
46	FOOD TRANS/STOR	0	2	3-4	5	2-4	2-3	2-4	2-4	2-4	2	3-5	3-5	3-5
47	SEWAGE DISPOSAL	0	2	3-4	5	2-4	2-4	1-2	1	2	1	3-5	3-5	3
48	RADIO COMM.	0	3	4	5	4	4	3	2	3	1	4-5	3	2

TABLE 1. POTENTIALLY IMPACTING ACTIONS (CONT.)

		1 ABANDON ISLAND	2 OUTPOST FACILITY	3 MIDLEVEL RESEARCH	4 FULL-LEVL RESEARCH	5 RECREAT/ EDUCATION	6 INSHORE FISH.	7 TRAP FISH.	8 AHI, ET AL FISH.	9 AKU FISH.	10 ALBACORE FISH.	11 SPORT FISH.	12 AQUARIUM FISH.	13 PRECIOUS CORAL
49	BULWARK MAINT.	0	2	4	4	4	4	4	4	4	4	4	4	4
50	BIOL. WASTE DISP.	0	1	2	3	2-4	2-4	3-5	2-3	2	1	2-3	1	2
51	SOLID WASTE DISP.	0	2	4	5	3	3	2	2	2	1	4	3	2
	OTHER ACTIONS IN FFS													
52	SMALL BOAT USE	0-3	2	2-4	4-5	3-5	5	2	1	2-4	1	3	3-5	1
53	MED/LONG RNGE BOAT ACTIVITY	0-3	1	2	2	2	2	1	2	3-4	1	2	1	1
54	UNAUTHOR. LANDING	0-3	1-2	1-2	1-2	2-4	2-4	1-2	1	1-3	0	1-3	1-2	0
55	OTHER IS. RESEARCH	0	1-2	2-4	3-5	1-2	0	0	0	0	0	0	0	0
56	INSHORE NET FISH.	0-3	0-1	1	1	1	5	1	1-2	5	0	1-4	1-4	0
57	INSHORE BOTTOM FISH	0-3	1	1	1	1	5	1-3	1	1	0	2-3	1-2	1

TABLE 1

DESCRIPTION OF POTENTIALLY IMPACTING ACTIONS

1. Boat Fuel Storage/Transfer

At present there are five diesel fuel tanks on Tern Island, each with an approximately 27,000 gallon capacity. Because of erosion and settling only four of these are serviceable. These tanks are filled from a fuel barge that is towed in from a mother ship. Transfer of fuel to vessels would be dependent upon the size of the vessels, the amount of fuel to be taken aboard and weather conditions. Very small vessels could be filled with portable fuel tanks that are filled on the island. Large vessels would be filled by a hose of some sort that reached the vessels moored in the adjacent turning basin or tied to a floating barge or newly constructed dock. Chances of fuel spills would be proportional to the amount of fuel transferred. Fuel usage on the island by the CG is approximately 230 gallons per day. Mid-range vessels would use 100-200 gallons/day/boat depending upon running time and size of engines. Maximum current storage on the island is approximately 100,000 gallons.

2, Boat Water Storage/Transfer

This action includes fresh water used in engines and for washing and consumption by boat crews. For this action it is assumed that no major modifications will be required on the present fresh water system. Storage capacity on the island is presently about 150,000 gallons in ten separate tanks.

3. Boat Gasoline Storage/Transfer

Gasoline would be used for small vessels only and could be stored in 55 gallon drums. Transfer would be made in portable tanks. Impact would be dependent upon amount used. The principle problem with gasoline is the safety hazard of storage and the possibility of contamination.

4. <u>Spare Parts/Supplies</u>

All large vessels would carry their own supplies. Storage at Tern would only be for those boats based on Tern. There may be a demand for occasional air transport of parts/supplies.

5. <u>Repair Shop (Boats/Motors)</u>

For small boats only. Larger vessels would take care of their own problems. This would involve the need for a separate structure, along with storage of parts/supplies.

6. <u>Frozen Fish Storage</u>

Intensity of impact is dependent upon the size of the catch to be stored. Amount to be stored is dependent upon 1) amount caught and 2) frequency of transfer to Honolulu. Facilities would have to be constructed. Some species (i.e. crustaceans) require processing first. Fish will require less storage space if they are first processed. Possibility of a flash freezing plant on Tern Island has been suggested. Electrical power demands (incl. fuel) for freezing facilities could be quite high, but undetermined.

7. <u>Refrigerated Fish Storage</u>

Impact is proportional to the size of the catch to be stored. Amount to be stored is dependent upon the amount caught. This will probably require flights every 3-4 days. Present refrigerator storage capability on Tern Island is insufficient to support a commercially viable fishery.

8. <u>Live Catch Storage</u>

Crabs, lobster and aquarium fish are stored alive. This requires holding tanks with running sea water or onshore netting to enclose an area adjacent to the island. New facilities are necessary.

9. Bait Rearing/Storage - Land

May be required for pole and line aku fishing if bait fishing or import is unfeasible. Present fishing methods produce 20 lbs. of aku per one lb. of bait. Size of supply required depends upon number of aku boats, distance to fishing grounds, mortality of bait, availability of other bait sources, etc.

10. Bait Rearing/Storage - Lagoon

Bait would be reared and/or stored in netted parts of the lagoon. The amount required is dependent upon the number of boats using it. Other open water mariculture activities are possible but not evaluated in this report.

11. Ice Plant/Transfer

Facility required will depend upon fishery and individual vessels. Vessels of sufficient size may substitute brine units for ice if storage is short term. Skiffs would require ice (100-300 lbs/day). Transfer to skiffs would be by hand at loading dock. Transfer to larger boats would be via skiff or from barge or newly constructed dock. Ice production could invovle major additional power and water demand. Alternatively, may ship in large supplies of ice by plane or ship.

12. Offloading of equipment

This is presently accomplished via a small pontoon barge. Unless major changes are made the barge use would be the most practical method. Impact would be proportional to the amount of use.

13. Skiff Dock Facilities

At present the skiff dock facilities are marginally usable, and could be used with little modification for limited use. Extensive use would require major repairs and possibly additional dock space.

14. <u>Mid-Range Vessel Dock Facilities</u>

At present, dock facilities are usable only by skiff. Docking for larger vessels would require extensive repairs and/or modifications as well as dredging, or the mooring of an acceptable barge.

15. <u>Long-Range Vessel Dock Facility</u>

Same as 14. Only possible for relatively small long-range boats.

16. <u>Skiff Moorage</u>

For all weather protection, moorings might be set on north and south of the island. Moorings would consist of a large anchor and other appropriate ground tackle. They would require periodic maintenance.

17. <u>Mid-Range Vessel Mooring</u>

More complex anchoring systems required with heavier ground tackle. Would have to be in dredged basin by island or out in lagoon.

18. <u>Long-Range Vessel Moorage</u>

Same as 17.

19. <u>On Land Skiff Storage</u>

For small boats only. Could be used for repair and/or storage. May only be area to park trailored boat or could build a shed in which to store them.

20. <u>Fuel Supply to Island</u>

Depends upon needs of each alternative. At present usage, each of the existing fuel tanks holds a 2-3 months' supply of fuel. The amount of fuel usage varies greatly with each of the alternatives. Method of transfer would vary with storage requirements.

21. Ship-to-Shore Communication

VHF for short range and SSB for longer range.

22. Waste Oil Disposal

Waste oil is a product of internal combustion engines. The amount produced is proportional to the number, size and usage of the engines. Ideally waste oil would be stored in 55 gal. drums for later removal, but it might also be allowed to percolate into the soil, be incinerated or dumped at sea. Impact would vary with amount of oil and method of disposal.

23. Skiff Movement

Skiff movement would be between Tern Island and the larger vessels for all offshore fisheries. Skiff movement for inshore fisheries and research would be within the refuge waters as well. Impacts would relate to number of skiffs, timing and location of movement.

24. Mid-Range Vessel Movement

Because of depths involved, mid-range vessel movements are limited to offshore waters, the deeper waters of the lagoons, and the dredged channel to Tern Island.

25. Long-Range Vessel Movement

Same as 24.

26. Sewage Disposal From Boats

Many vessels, especially older ones, dispose of raw sewage by pumping it directly overboard. The intensity of impact from this practice will depend upon the number of vessels, where they pump their sewage, the extent of voluntary compliance, and the enforcement of regulations to control this activity.

27. Bilge Pumping

Bilge pumping is primarily used for the disposal of petroleum products, water and other matter that accumulates in the bilges of vessels. The extent of this activity is primarily related to the conscientiousness of the vessel operators. Present regulations prohibit draining of petroleum products into the bilge of a vessel and prohibit discharge of bilge wastes into State or Federal waters.

28. On Land Vehicle Use

Support of boat activities will require vehicles to transport fish and supplies, dispose of waste materials, etc.

29. Dredging

It is unlikely that dredging of the access channel will be required. However, if it is necessary for mid-range and long-range vessels to tie up to the existing dock, some basin dredging will be required. Additional impacts relating to dredging will depend upon the methods of dredging and location of dredge spoil disposal.

30. Channel Marker Maintenance

If any vessels larger than skiffs are to enter the area, channel markers are essential. The absence of appropriate markers could increase the chance of major accidents, including fuel or oil spills.

31. Mother Ship or Barge

The impact of a mother ship or barge is related primarily to its location, its moorings and its personnel. Such a facility could be stationed outside the reef or adjacent to Tern Island. The chance of dragging its moorings and breaking up on the reef is probably the most serious risk.

32. Light Twin Engine Aircraft

These consist of small aircraft capable of carrying 8-10 passengers or 1500-2000 lbs. of cargo that can land at Tern Island, utilizing only a portion of the runway.

33. DC-3 and Similar Sized Aircraft

Capable of landing at Tern Island, but requiring most of the runway. These aircraft are large enough to profitably haul freight, including fish. May also be used for major supplies for the other options.

34. Large Aircraft (e.g. C-130)

These planes are capable of carrying large quantities of freight, but can land and take off only with difficulty and risk. Vulnerability to damage from bird strikes increases with use of turbine engines. Major use at Tern Island would be for Coast Guard Rescue.

35. Runway Maintenance

Rolling and matting of the runway is necessary on a repetitive basis. Large aircraft require more prepared surface and more maintenance. Runway receives damage from prop blast (particularly from larger aircraft, wave action and wind and rain erosion.

36. Bird Control

Control of nesting Sooty Terns at the east end of the runway has been necessary in recent years to reduce air strike hazard, particularly for large aircraft. Small aircraft do not need all of the strip so control of birds is less critical.

37. Aviation Gas Storage

If there are frequent flights by small aircraft it will be prudent to store some avgas for safety considerations and to allow aircraft use in the vicinity of FFS (i.e. fish spotting, research). Avgas storage creates safety hazards and potential for contamination.

38. Aircraft Storage

In case of inclement weather it may be prudent for small aircraft to remain overnight. It would be necessary to have at least tiedowns for these aircraft, and covered storage may be considered.

39. Room/Board

Several management options require on-island living facilities. Assumption is made in this study that present facilities are adequate to support even full level options (i.e. 20-25 people).

40. Research Laboratories

Laboratories on Tern Island would be utilized by scientists for research or education. Type and magnitude of facilities would vary considerably.

41. Recreation

Tern Island outdoor recreation opportunities include tennis, jogging, football, basketball, volleyball, etc. The Coast Guard has used adjacent waters for swimming, waterskiing, fishing and skindiving.

42. Educational Uses

Many parts of the island have the potential to be used for educational purposes (i.e. participation in research, nature study, filming).

43. On-Island Field Research

On-island research would include studies of seabirds, nearshore marine life, weather, and support of other studies requiring lab facilities.

44. Fuel Demand On Island

Fuel is primarily required for generating electrical power. At present three 250 KW generators satisfy Coast Guard power needs. Electrical power is porportional to the number of people present as well as other major usage (i.e. fish processing and storage, ice production).

45. Water Storage

Fresh water can be derived from entrapment of surface runoff and from desalinization. There is considerable disagreement regarding adequacy of present catchment, dependability of supply and storage capability to handle greater demand.

46. Food Transport and Storage

Food for all of the inhabitants and for all fishermen not capable of carrying their own supplies would have to be brought to Tern Island and stored. Both refrigerated and dry storage capability would be necessary.

47. Sewage Disposal

Existing discharge of treated sewage through contained STP. Impacts of alternative management options would vary depending on methods of treatment and discharge and amount of sewage produced.

48. Radio Communication and Navigational Aids

For any of the options involving continued use of Tern Island, the assumption is made that communication will be maintained between vessels within FFS and Tern Island for safety reasons. Also, the need for navigational aids on the island will depend upon frequency of aircraft use and type of aircraft used.

49. Bulwark Maintenance

Steel sheet piling protects the sides of the island from wave action. They must continually be replaced and/or repaired. Need for repair and type of repair utilized (i.e. sheet pile, concrete bulwark, revetment, etc.) will depend on intensity of development on island, need to maintain entire runway, and long-range management objectives.

50. Biological Waste Disposal

It will be necessary to dispose of the waste products from fish and crustacean processing as well as other bio-degradable wastes.

51. Solid waste disposal

In the past solid waste has been disposed by incineration, burying on island, and dumping at sea. Methodology employed in the future will depend on intensity of use and type of waste produced.

52. Small Boat Activity Within FFS

Intensity of small boat activity within the refuge waters will vary significantly with option(s) selected. In view of the fact that most of the refuge can not be seen from Tern Island, it will also be necessary to police activity in the area by small boat. The amount of policing necessary will in part be proportional to the number of other boats and the type of activity. This will create additional impacts.

53. Mid/Long Range Boat Activity in FFS

Boat movement within the refuge, but outside the dredged channel will be limited by navigational hazards, regulations and voluntary compliance. Presumably the major use of mid-range boats in the vicinity of islands would involve possible baitfishing by aku boats. Some use of refuge waters will be made as protected anchorage during inclement weather.

54. Unauthorized Landing on Other Islands in FFS

(self explanatory)

55. Other Island Research in FFS

Impacts wil vary depending upon number of researchers, timing and duration of stay, types of research, etc.

56. Net Fishing Within Refuge Waters

Netting in lagoon waters is useful in catching baitfish and other species. The impact of the action will vary with methodology, location, duration and timing of the action.

57. Inshore Bottom Fishing within Refuge Waters

Consideration here is restricted to authorized consumptive harvest within refuge waters. Impacts will vary with location and frequency of activity, and the fishing techniques employed in specific areas.

AGENCY MANAGEMENT OPTIONS

For the purpose of discussion, we have separated the discussion of various management plans for Tern Island from the decision regarding which agency or agencies should implement the plan. This attempt at simplification is not totally free of its own complications, because the issues are interrelated. The practical feasibility of implementing any particular management plan varies radically when different agencies or organizations are compared. Important considerations include expertise of personnel, financial resources, logistical capabilities, jurisdictional responsibility and potential conflicting resource use policies or objectives. The question of agency responsibility for the Tern Island decision is also intimately tied into the ongoing refuge boundary dispute, and marked differences of opinion regarding specific legal responsibility and jurisdiction.

Much of the input provided in the interview process was directed towards the issues of agency responsibility. Not surprisingly, most representatives of State agencies felt strongly that the State government should have primary or sole responsibility for management decisions at Tern Island. At least two mandatory contacts in State legislature went so far as to refuse to speak with MANTA because their cooperation might be construed to indicate recognition of FWS legal jurisdiction at Tern Island. Most other contacts recognized the FWS claim to jurisdiction and felt that this agency should manage the facility independently or in cooperation with other State and Federal agencies. Recommendations regarding possible joint management took on several forms including 1) one lead agency with others providing advisory input, 2) joint management by group authority, or 3) joint management with specific areas of responsibility. Several contacts also suggested that a private non-profit organization (i.e. Smithsonian Institute), an academic institution (i.e. University of Hawaii), or a commercial outfit with appropriate experience could operate a research and/or fishing support facility under direction from one or more responsible agencies.

Perhaps the most relevant issue to be considered in reviewing the agency management options is the legal jurisdiction over the land, water, and fish and wildlife resources in the area. In view of the ongoing jurisdictional debate, a long range decision regarding agency management of a Tern Island facility may be even more premature at this time than a decision that would affect resource use without adequate impact assessment data. However, until such time as the FWS claim to jurisdiction over Tern Island and refuge lands and waters is successfully challenged and overruled, the FWS is obligated to maintain its lead agency position in the decision making process.

Without attempting to recommend a specific course of action, it is valuable to consider the pros and cons of individual agency management that were discussed during the interview process. This discussion, representing the views of various interview contacts, is certain to be controversial. However, it does point out some of the major considerations that will affect long-range decisions for agency management.

U.S. Fish & Wildlife Service (FWS) Management

The primary justification for FWS as a sole manager or lead agency is the current legal status of the refuge boundaries and management responsibility. The long history of resource management in the Northwestern Islands and throughout the National Wildlife refuge system also contributes to the ability of this agency to continue management of the area. Legal responsibility for protection of endangered species by this agency also necessitates a participatory or lead role in management and enforcement of pertinent regulations. The refuge division of the FWS has been conducting wildlife research in the Northwestern Islands since the arrival of the first refuge manager in 1964, and has actively supported the research work of others. The research division of the FWS has not conducted extensive research with HINWR, but could assume a lead or cooperative role in the establishment and management of a Tern Island research station. There is ample precedent and a long history of experience within the agency to successfully establish and operate field research stations, in Hawaii and in remote locations in Alaska and other states. The FWS has also directed the activities of other agencies and private commercial operations on several other refuges throughout the country. In many areas, agreements have been developed for operation of particular aspects of a refuge program by others (i.e. camping areas, hunting programs, concessionaires, etc.). Some of these activities have included commercial operations (oil and gas leases, grazing, mowing of hay, trapping, etc.), but they are generally part of an overall habitat management program or part of the original agreement by which the FWS acquired refuge lands. It should also be noted that in a thorough review of the feasibility of transferring management of national wildlife refuges to other agencies, the FWS concluded that there was no evidence that such an action would result in savings in funds, supplies or manpower, unless the current values of the refuges were compromised. On a nationwide basis, it was determined that transfer of refuges to other agencies would fragment the refuge system, inhibit effective regulatory control by the Secretary of Interior, prevent a cohesive national effort and ultimately cost the taxpayer more because the alternative agencies would not be fully prepared to accept the new responsibility (Ref. 79).

Several arguments against sole management of a Tern Island facility by FWS were raised in the interview process. The primary argument among representatives of State agencies was the questionable legal title to Tern Island and the disputed refuge boundaries. It was also noted that FWS does not have sole regulatory jurisdiction over the wildlife resources. Of particular note is the joint responsibility between the FWS and NMFS for protection of the monk seal and green turtle. The lack of appropriate experience of the local FWS office in operating a field research facility was pointed out. Some concern was raised that the FWS is unsympathetic with the concept of commercial exploitation in refuge waters, yet has been unable to adequately justify why both commercial use and wildlife conservation cannot be accomodated. Some feel this "anti-exploitation" attitude would inhibit successful joint use of the Tern Island facility and fishing interests would be given lower priority in management. On an island with limited support capability, fishing interests would get the "short end of the stick." The point was also raised that FWS may not always be willing to aggressively enforce its own regulatory authority. Failure to pursue legal proceedings against the Navy for bombing within the Kaula Island seabird colony has been suggested as an example where the FWS may have "backed off" as a result of their ongoing negotiations with the Navy.

One final argument against FWS management of a Tern Island facility relates to the problem of financial support. Economic considerations are discussed in some detail later in this report (Sect. 7-1). Certainly the actual cost of operation to the managing agency for a research station would vary radically with the level of development and the extent to which individual researchers were supported by other institutions or agencies. Presumably, those agencies or industry interested in potential fisheries support would cover the costs associated with such a program on Tern Island, regardless of which agency had ultimate management control. Yet, the simple maintenance of the minimum outpost facility on Tern Island is anticipated to cost in the neighborhood of $190,000 per year, (B. Giezentanner, pers. comm.) independent of infrequent but very costly channel dredging, repair of the bulkheads and other activities designed to prevent structural deterioration of the island itself.

In assessing whether or not FWS could cover the additional costs of a Tern Island station, it is difficult to determine exactly what funding FWS has directed toward the operation of the HINWR, because the past budgets do not separate funds spent on this refuge from those spent on other refuges in the State. Between fiscal years 1972 and 1979, annual refuge expenditures have increased from $42,500 to $265,000. Refuge staff has increased from two persons to six full time staff, three part time staff and several seasonal technicians/biologists in the same time period. Although the increasing budget for refuge management appears substantial, there is concern that there would be insufficient FWS funds directed to management of the Tern Island facility. One reason for this concern has been the failure of the Honolulu area office of FWS to obtain more than token funding for its role in the ongoing Tripartite Cooperative Agreement. In FY 79 only $37,000 was set aside for FWS participation in the study, whereas the other agencies or institutions in this state, with the exception of the Division of Fish and Game, have contributed considerably more to the cooperative effort (NMFS - $576,000; Sea Grant - $335,000; Marine Affairs Coordinator - $150,000; University of Hawaii - $60,000; Division of Fish and Game - $25,000) (Ref. 168). It was also noted that national wildlife refuge construction and major rehabilitation funding in real terms has declined over the last decade, (Ref. 79) so concern that FWS may not be willing to allocate sufficient funds to support a facility at Tern Island appears justified.

National Marine Fisheries Service Management

None of those persons interviewed in this study suggested that NMFS should be the sole managing agency of a Tern Island facility, although several people felt this agency should play a participatory role in management with FWS and other agencies. It was noted that NMFS, as the lead agency in the Tripartite study, is directing far greater amounts of money into the project than others. In this study, NMFS has responsibility for assessing the insular, seamount and pelagic resources in waters overlying depths between 20 and 600 meters. In addition, the Marine Mammal Division of NMFS is supporting a continuing study of the monk seal in the Northwestern Hawaiian Islands. A long history of research experience within the area has been cited as a justification for involvement in Tern Island management. Shared jurisdictional responsibility with FWS for threatened green turtles under the Endangered Species Act of 1973, and separate jurisdictional responsibility for the monk seal and cetaceans under the Marine Mammal Protection Act of 1972, were also pointed out as compelling reasons for NMFS managerial responsibility.

On the other hand, NMFS has no apparent legal claim to land or waters within the designated refuge boundaries and therefore may not be the logical agency to assume managerial responsibility. In addition, a potential if not real internal conflict of agency objectives may hinder the ability of NMFS to carry out its responsibilities effectively. It is apparent, even with the shortage of pertinent life history data, that inshore fishing activities within refuge waters may have an adverse impact on monk seals and turtles and their habitat (see Section 7K). Concern has been raised that an agency charged with the responsibility of protecting these species and with improving the efficiency of commercial exploitation of marine fishery resources, cannot be totally objective when responsibilities conflict.

Hawaii Department of Land and Natural Resources (DLNR)

Several persons interviewed during this study indicated that DLNR should be a lead or participating agency in management of a Tern Island facility. No one suggested that DLNR have sole managerial responsibility. The question of legal jurisdiction is unsettled, although the FWS claim to island ownership has yet to be challenged in court. The State has its own regulatory authority for protection of wildlife resources and, among its staff, considerable research experience in the Northwestern Hawaiian Islands. If the current boundary dispute is settled in favor of the State, and DLNR assumes managerial authority over inshore waters in the Northwestern Hawaiian Islands, protective designation of specific areas could still occur under State authority (i.e. Marine Conservation Districts, Natural Area Reserves). The islands of the HINWR are also within a State wildlife refuge and derive protection under this designation. The State Seabird Sanctuary could also be expanded to include the Northwestern Hawaiian Islands. In view of the legislature's support of research to investigate marine resources it is likely that financial and legislative assistance would be generated to insure maintenance of the Tern Island facility.

Concern was raised during the interview process that the State should not be the lead agency in management of the Tern Island facility because of a poor track record in the conservation of both marine resources and endangered species. The overfishing of nehu in coastal waters was cited as one example of inefficient management. It was also noted that DLNR had not proven itself capable or willing to effectively protect seabird resources on islands offshore of Oahu from trespassers, so it may be unrealistic to to believe that the State could or would play the enforcement role in the NWHI. Although the State has its own regulatory authority for wildlife conservation, including a State Endangered Species Act, it has failed to make the necessary adjustments to that act to qualify for federal funding available under the Federal Endangered Species Act. Each year, DLNR returns several thousand dollars of federal money that could be used for wildlife conservation programs if matched by state appropriated funds. It was also noted that during the period in which DLNR was under cooperative agreement with the Department of Interior to manage and administer lands in the Northwestern Hawaiian Islands, FFS waters were commercially fished by private interests, with no attempt to regulate this activity or assess the impacts. Turtles and fish were flown out from Tern Island to Honolulu. One visitor to FFS in 1959 reported observing several turtles that had been slaughtered but not harvested. Finally, overwhelming support of commercial exploitation of Northwestern Hawaiian Island waters among several State legislators, and representatives of DLNR raises the question as to how the various potential uses of Tern Island and FFS would be ranked in priority, and how well the State would police itself.

Other Agencies and Institutions

Several interview contacts indicated other agencies or institutions that could be involved in a joint management option for Tern Island. These include the Marine Affairs Coordinator, Sea Grant, the University of Hawaii and the Smithsonian Institute. All of these organizations could contribute expertise and potentially funding to the management of a Tern Island facility. It was also suggested that a single agency or group of agencies could direct the efforts of a private contractor, hired to operate the facility. One example cited was Global Associates at the Eniwetok marine lab. Another person, in reference to the potential for public use of the facility, cited an example from Heron Island in Australia. A private concessionaire runs this facility on contract to the Australian government and is responsible for all logistical support, including transportation, housing, food, boats and other facilities. It was pointed out that an organization such as the Smithsonian would have to report to all organizations with enforcement responsibilities and therefore there would not be conflict of interest in terms of enforcement.

Joint Agency Management

In view of the overwhelming support among the interview contacts for some form of interagency management agreement at Tern Island, this alternative deserves more thorough investigation. As noted earlier, this arrangement could entail a lead agency with advisory input from others, a joint management group with overall responsibility or a joint management group with individual areas of responsibility. Although many of those persons expressing an interest in cooperative management appeared to favor the second alternative, it was also noted by several people that this plan may be simple to conceive but difficult to implement. The two agencies with the most constraining legal responsibilities for wildlife conservation (FWS, NMFS) would obviously have to establish some basic ground rules within which all parties could operate. This is the approach that has been taken in the cooperative agreement between the Coast Guard and FWS for use of Tern Island and between all parties involved in the ongoing Tripartite Cooperative Agreement. NMFS and FWS would also have to exercise enforcement authority at the site, or delegate that authority where legally possible.

Not surprisingly, those individuals expressing support for a cooperative management scheme with a single lead agency played it pretty close to the party line in the recommendations of which agency should take the lead. Some questioned the feasibility of a management plan in which authority was shared equally, in view of the major decisions that would need to be made regarding use priorities at the Tern Island facility. Recommendations were made that a management group for a research facility should include scientists familiar with Northwestern Hawaiian Island resources. This group would review various research proposals for the facility and FFS area to insure compatibility with wildlife conservation, other projects and research objectives.

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Introduction

As indicated earlier, discussion of the affected environment in this assessment was not part of the MANTA contract with FWS. This was in part due to the availability of pertinent published information that could easily be incorporated by FWS into the continuing assessment process. It was also recognized that a major focus of the ongoing Tripartite Cooperative study was to obtain the necessary data to evaluate the status of fish and wildlife resources in the Northwestern Hawaiian Islands, and that study is not scheduled for completion until 1981. Rather than provide an exhaustive treatment of data available at this time, or attempt to predict the results of the Tripartite study, we have chosen to provide only a brief descriptive overview within each of several enviornmental categories. This should be sufficient at this time to consider the real and potential environmental consequences of various management options.

One cannot realistically describe the affected environment and the effects of various management plans at Tern Island, without consideration of the indirect, but often far more significant, impacts of these actions elsewhere in French Frigate Shoals and the entire archipelago. To the extent that these impacts can be predicted with reasonable certainty, they are considered in this report, although for the most part, emphasis here is directed to French Frigate Shoals.

Several interrelated factors must be taken into consideration in a thorough discussion of environmental consequences or impacts of various management alternatives. Important questions to be answered include the following:

1. When: Will the impact be immediate or will it occur at some later date? For how long will there be an impact?
2. Where: What will be the area affected?
3. Magnitude: How large will the impact be?
4. Significance: How significant is the impact? (For example, as loss of 100 individuals of a common species and 100 individuals of an endangered species would be of the same magnitude, but the significance of the impact to the endangered species would be greater).
5. Certainty: What is the probability that the impact will occur if the action occurs?
6. Cumulative impacts: Will the impact under consideration add to other impacts of a similar nature to create a more significant cumulative effect?
7. Indirect or direct: Will the impact occur as a direct result of the action or will it result from a subsequent anticipated action?
8. Reversibility: Can the impact be reversed by a subsequent action?
9. Mitigation: Can the impact be mitigated, compensated for or eliminated through some corrective action?
10. Adverse or positive: Can the nature of the impact be described as adverse or positive? (Note that this characteristic is often subject to interpretation).

Brief mention should be made at this point regarding a definition of the "without" condition in this study. In order to fully understand the discussion of anticipated impacts, it is first necessary to distinguish between the historical condition, the current condition and the "most probable" future condition of Tern Island and neighboring waters, independent of the project. As is described in more detail later, Tern Island was historically one of several small, sparsely vegetated, sandy islets within FFS. As a result of extensive dredging in neighboring waters, and placement of steel pilings, the original 11-acre sandy islet was converted into a 57-acre flat island with no vegetation. Buildings were constructed to support a naval air facility. In the 37 years since the island was reconstructed, the natural and human environment has undergone many changes. In its current configuration, approximately 16 acres of the island is covered with vegetation. Many of the buildings have changed, but the location of the intensively developed portion of the facility has not changed appreciably. When the Coast Guard leaves the island on 30 June 1979 the "most probable" future without any action by FWS or other agencies will be an accelerated deterioration of all manmade facilities, uncorrected erosion of the island structure, eventual dispersal of vegetation over a greater portion of the island, and an increase in the abundance and distribution of wildlife on the island, particularly the nesting seabirds.

HYDROGRAPHY/OCEANOGRAPHY

Affected Environment

French Frigate Shoals lie between latitudes of 23 degrees 37'18" and 23 degrees 52'50" North and the longitudes 166 degrees 03' 14" and 166 degrees 20'04" West. At this location, it is nearly midpoint in the 1600 mile long Hawaiian archipelago. The atoll consists of a crescent-shaped reef whose long axis is 19 nautical miles in a northwest to southeast direction. The outer arc of the crescentic reef is nearly continuous while the inner arc is broken in many places. The lagoon within the reef arcs is approximately 140 square miles in size.

One basaltic island (La Perouse Pinnacle) and twelve small sandy islets are found within FFS, most along the margin of the inner arc reef. Total acreage of these islands has been identified as 111.3 acres, although this figure will vary as changing weather conditions cause sand to erode or accrete around the smallest islets (Ref. 7). Tern Island is the largest islet in the atoll. In its present configuration it is approximtely 57 acres, although it has been extensively altered from its original size, estimated at approximately 11 acres (Ref. 7).

The depth to the sandy bottom of the lagoon averages about 3 fathoms, while the protected waters immediately west of the inner reef vary from 5-20 fathoms. A bank with depths of 8-20 fathoms extends about 8 miles westward from the midpoint of the inner reef. The bottom in the western area is coral and hard sand. In some areas adjacent to the inner reef, numerous coral heads extend to within 1-5 fathoms below the surface.

Current movement in the Hawaiian region is from east or northeast to west or southwest. Variable currents have been noted within FFS and a southwestward current of 2 knots has been measured. Circulation within atolls varies considerably with reef configuration, depths, and gaps and passages in the reefs. The ocean waves nearly always break over the outer reef at FFS, but the inner leeward reef is seldom marked by breakers. Swells within the lagoon generally run 4 feet, but can run as high as 8 feet during windy days.

Environmental Consequences

In contrast to the other environmental categories under discussion there are few ways in which any of the alternative management plans for Tern Island can impact significantly upon the hydrography or oceanography of the area. Major dredging occurred in the vicinity of Tern Island in 1942, to provide fill for the airstrip island, to clear a 12,000foot ship channel and to create a 8,000 foot seaplane landing area. Conceivably the creation of the 20 ft. deep ship channel has had a localized effect on circulation patterns, but the magnitude of this effect is uncertain. If maintenance dredging is undertaken to restore or enlarge the channel or turning basin, some minor alteration of nearshore currents may occur, but the extent or significance of this effect is impossible to determine without intensive survey of circulation patterns in the vicinity of the island. Wave action and nearshore currents have also been responsible for a decrease in width of the island at the west-southwest end and an increase in width along the east-southeast side of the island through accretion of sand. This action can be expected to continue, and perhaps even accelerate in the future if existing shore retaining walls are allowed to deteriorate uncorrected.

The existing oceanographic characteristics of the area around Tern Island and elsewhere in FFS will affect the feasibility of various management options under consideration. There are no all-weather anchorages for large vessels, but the inner reef does provide some protection from choppy seas and ground swells. The best holding ground southwest of FFS is at depths of 13 to 15 fathoms in sand bottom. Under normal tradewind conditions, Coast Guard vessels commonly anchor at a point 0.7 miles to 1.2 miles south-southwest of the entrance to the Tern Island access channel. The access channel is only used by small craft because of the uncharted coral heads and limited space in the turning basin. Most supplies are moved in and out from the island by towed barge or skiff. Any of the alternative management plans that require offloading of large vessels at Tern Island which could not be accomodated by barges or skiffs, would probably require dredging of the access channel. At the very least, retention or replacement of the existing Coast Guard channel buoys would be required for continued access to the island.

The lack of all-weather anchorages and navigational hazards adjacent to the inner reef diminishes the opportunities for safe exploitation of inshore areas by fishing vessels. The first shipwreck at FFS was recorded in 1859, and at least 6 other vessels have run aground or sunk in these waters since that date. It has been suggested that the hazards of unsafe anchorages could be minimized by the placement of permanent mooring buoys in sufficiently deep water west of the inner reef. FWS now prohibits boats to enter the refuge waters without permit. In the event that the State assumes jurisdiction over the inshore waters, existing State law empowers the Department of Transportation to regulate movement or anchorage of boats in State waters. This authority to limit numbers of vessels and duration of anchorage has been used in particularly sensitive waters (i.e. Marine Conservation Districts, Natural Area Reserves) in the main islands, but enforcement would be difficult in this remote area.

GEOLOGY

Affected Environment

The present characteristics of islands of the Hawaiian archipelago evidence the fact that volcanic activity started at the northwest end and advanced southeastward, where it still continues only on the island of Hawaii. Most of the Northwestern Hawaiian Islands are sandy atolls perched atop the eroded peaks of submerged volcanoes. Erosion by wind, waves and rain, together with fluctuating sea level in the Pleistocene era, set the scene for the continuing growth of coral and coralline algae that forms these atolls. As Wiens (Ref. 173) points out, there is no simple definition of atoll that is universally applicable. His inclusive definition is as follows: "A more or less continuous emerged or slightly submerged calcareous reef surrounding a distinctly deeper lagoon or several such lagoons without emerged volcanic islands, which stands apart from other islands, and whose upper seaward slopes rise steeper than the repose angle of loose sediments from a generally volcanic foundation too deep for the growth of reef corals."

French Frigate Shoals is unique geologically among the Northwestern Hawaiian Islands in that both emergent basalt (La Perouse Pinnacle) and calcareous atoll are adjacent to one another. The islets lining the lagoon at FFS are composed of loose sand, shells and coarse coral rock rubble. Some humus can be found within vegetated areas of several islets.

The geology of Tern Island has been more radically altered than any othersandy islet or basaltic island in the Northwestern Hawaiian Islands. Wetmore (Ref.in 7) described Tern Island in 1923 as "about 600 yards long, by 150 yards wide. The eastern half is a long curving sandspit, from 6-8 feet above the sea. The western half which is the site of the bird colonies is from 10 to 12 feet above the sea and has a soil of fine coral sand." He estimated the size of the island at 11 acres. The reconstructed island, when first built, was 3,100 feet long and 350 feet wide. Steel sheet piling held the 660,000 cubic yards of sand and coral dredged from nearby waters. Although sand has accreted along parts of the shore and eroded elsewhere, the structure is basically the same as it was when first constructed in 1942. Deterioration of sheet piling, particularly on west and north shores, has also occurred.

CLIMATE

Climate of the Pacific atoll realm is marine and tropical in character. Normal winds in most Pacific atolls are trades. These breezes moderate the typically high humidity. Land is too low and small in area to significantly affect open ocean rainfall patterns. On drier atolls, drought periods may be relatively frequent and extended. Most atolls are subject to periodic battering by storm winds and waves directly affecting the reef structure and terrestrial environment.

The most northern atolls in the Pacific are found in the Hawaiian archipelago. Climate data for French Frigate Shoals, lying centrally in the island chain, was first recorded in 1943, after establishment of the U. S. Naval Air Facility. Data recorded by the U.S. Coast Guard for the National Weather Service are available until the present time. Data gathered between 1951-1962 were reviewed by Amerson (Ref. 7) and are briefly summarized here. Temperature variation is slight; a mean annual temperature of 75.5 degrees and a mean annual range of 10 degrees were recorded. Mean annual precipitation for the record period was 45.29 inches, with an average of more than 60% of the total annual rainfall in the four month period, December through March. Thunderstorms were recorded only in April and December. Winds recorded during the 1951-1962 time period demonstrated an easterly prevailing wind direction with surprisingly little variation. Annual mean windspeed was 12.6 knots, with a range of 5 knots. Mean winter windspeed was 14.3 knots, while in summer it was 11.5 knots. The maximum sustained wind record during the period was 52 knots from the east-northeast in December. Sky cover is relatively consistent throughout the year, ranging in percentage from 46% in February to 52% in July and August.

Amerson (Ref. 8) noted that storms or typhoons are rare in the Hawaiian Islands, although FFS has felt its share of severe weather. Typhoon Able passed south of FFS in August, 1950, forcing evacuation of the East Island LORAN station for nine days, but damage was negligible. Typhoon Dot forced evacuation of the Tern Island station between 5-9 August, 1959, but there was no storm damage. Other storms with a noticeable increase in rain, winds and high seas were noted in October and November, 1946; January, 1949; January, 1953; January, 1954; and September, 1957. Tidal waves are also an infrequent occurrence at FFS, but even rare events take on significance on an island with little or no protection. Tidal waves were recorded in April, 1946; November, 1952 and March, 1954. The most seriously damaging recorded event was on December 1, 1969. Very large waves washed over the 8 foot high island, flooding living quarters and equipment buildings. Coast Guard personnel were evacuated by helicopter from the top of a building. Damage to the facilities was extensive. In addition, the seawall was badly crushed in places, and the substrate was badly eroded along the north shore. Much of the vegetation on the northwest side was destroyed. Damage to the station was later placed at $142,000 (Ref. 8).

Environmental Consequences

It is unlikely that any of the proposed alternative management plans could have a significant effect on the climate at French Frigate Shoals. However, the climatic conditions in the area do affect the feasibility of various options, and the effect that these options will have on other aspects of the natural environment. Climatic conditions are obviously of little or no significance if the abandonment alternative is implemented. Winter storms would accelerate the deterioration of the island in the absence of seawall maintenance. Equipment and facilities left behind would deteriorate rapidly as well.

Recently constructed facilities on the island were built to withstand (or tolerate) infrequent wave overtopping of the island and periodic high winds, but the frequency and severity of these events in the future will obviously affect the rate of deterioration of these facilities. Implementation of options that direct sufficient funds and manpower to maintenance and rehabilitation of equipment and facilities will prolong their life and utility. It is unlikely that the "outpost facility" option will support the optimum level of maintenance, particularly if person(s) stationed on the island also spend their time in support of limited research or fishing activities.

Climatic conditions, particularly relating to extreme events (storms, tidal waves, high winds), will directly affect the safety of personnel for all options. The abandonment option carries with it significantly greater risks for fishermen or other boaters in the vicinity of FFS because deterioration of the runway will quickly eliminate the opportunity for aircraft evacuation of sick or injured personnel and the lack of a permanent station with radio facilities will hinder search and rescue operations.

Seasonal climatic variations, particularly relating to the greater frequency of winter storm events, would lower the viability of the Tern Island station for all uses requiring frequent boat movement within the refuge waters and out to sea. Only vessels that could be pulled from the water (skiffs) or safely weather these storm conditions could remain in FFS over winter. Seaworthy Hawaiian vessels capable of withstanding the winter conditions include the EASY RIDER, TAHEI MARU, LIBRA and KEOLA, but it is doubtful that few, if any, other local boats could regularly use, or would choose to use, the area in winter. Boats from the albacore fleet now beginning an experimental fishery program at Midway Islands might conceivably choose to fish FFS waters during the winter months when the albacore fishery is inactive. These boats could shift direction into fisheries (e.g. bottomfish) around FFS. The inshore skiff fishery would have the option of protecting the boats by removing them from the water during severe weather. However, it is possible that the frequency of days that are unfishable would lower the economic viability of the fishery to the point where continuation through the winter was unjustified. The viability of any of the fishery options requiring air transport would also be hampered by the unreliability of flights during poor weather conditions. The remoteness of the station and the lack of enroute visual references for navigation would also raise some serious safety considerations regarding frequent air travel during adverse weather. Disestablishment of the LORAN-A station will force pilots to depend upon LORAN-C, VOR and ADF navigation.

Independent of the safety considerations mentioned, climatic conditions directly affect the feasibility of certain field activities associated with each of the management options. Unpredictability of weather and adverse weather will directly affect the utility of small boats for fishing, research, education and recreation in FFS waters. All pelagic fisheries are adversely impacted by foul weather conditions, particularly those activities including handling of traps, trawling or submersible work for precious coral and trolling for sport.

Although the living facilities at Tern Island have been rehabilitated and considerably improved since the December 1969 overtopping of the island, the residents of the island under any of the alternatives will not be totally free from safety threats due to adverse weather. Provision will be necessary to insure that radio equipment and other necessary emergency supplies are accessible and protected in the event of storm conditions that may force residents to seek refuge on the tops of buildings.

Much has been said about potential problems associated with serious storm conditions. It should be noted that extended periods of drought also directly affect the viability or desirability of various management options. Present water storage and distillation capability (see <u>Water Supply</u>) on the island are believed to be adequate to sustain a population of 25 persons (Ref. 47). However, periods of water shortage due to prolonged dry periods in past years have necessitated careful water conservation efforts. The situation could be seriously aggravated if one or more of the water storage tanks was inadvertently polluted or poisoned. Significantly greater numbers of people have been sustained on the island for extended periods by provision of additional water storage (i.e. during station rehabilitation) or with greater distillation capability (i.e. during early Navy air station use). Those management options that involve less than a full complement of on-island people obviously stand the least risk of future water shortage due to extended drought. Demands for water for ice and for fishing boats in the area would also aggravate the problem of periodic drought, particularly because the peak of the fishing activity would coincide with the driest months of the year.

HYDROLOGY AND WATER SUPPLY

Affected Environment

The material that makes up the typical sandy atoll is generally so porous that drainage by percolation is rapid. Typically,low sandy atolls have no running or standing surface water. Percolating rain water makes contact with salt water that has infiltrated. The fresh water, being slightly lighter, tends to float on the surface of the salt water. The fresh water forms a "lens" over the salt water. The shape and level at which the lens forms will vary with the geology and shape of the island, as well as the patterns of rainfall and tidal fluctuations (Ref. 173). Where excessive mixing occurs, brackish conditions will prevail.

Data of the availability and characteristics of groundwater on atolls of the Northwestern Hawaiian Islands are sketchy. Apple (Ref. 14) noted that early settlers on East Island at Midway found brackish water that "was not pleasant to drink" by digging 8-9 feet below the surface. On Sand Island (also Midway atoll) water was found at 5-6 feet that was "very good but charged with lime." Walker (Ref.in 14) noted that water was taken from the galvanized roofs of the Laysan guano factory because the "water from the wells is too brackish to drink, and not even fit to wash in." In contrast, Capt. John Paty in 1857 (Ref.in14) found potable water on Lisianski Island 5 feet below the surface in a dried lake bed. Bryan (Ref. 28) notes that brackish water can be obtained by digging shallow wells on Pearl and Hermes Atoll, while Galtsoff (Ref.89) could not find fresh water bearing stratum on Southeast Island at Pearl and Hermes Atoll.

Amerson (Ref. 7) indicated that "no fresh water exists on any of the islands (at FFS); perhaps brackish water can be obtained by digging shallow wells on the larger islands." We are unaware of any records of potable groundwater on Tern Island at FFS. Surely the massive alteration of the original island in 1942 created a situation in which the newly created "island" established a totally new groundwater regime, influenced considerably by the repetitive packing and compressing of the runway surface and the absence of surface vegetation. It is apparent that infiltration on the runway surface is still altered by maintenance operations, as it is not uncommon for puddles of rain water to collect and remain on the runway for several days after showers. In contrast, water falling directly upon the vegetated borders of the runway, or running off the runway, quickly infiltrates into the ground. The groundwater regime on Tern Island has presumably been further altered in an undetermined way by the burial of extensive facilities (fuel and gas tanks, quonset huts, etc.) during the original construction operation. Also, the ongoing practice of burying solid waste in excavations next to the runway, and disposal of waste oil by gradual percolation into the ground, has presumably altered both the distribution and potability of groundwater.

Groundwater has never been a source of potable water on Tern Island, at least since construction operations in 1942. During the war, the Naval Air facility supported as many as 127 men (Ref. 7). Fresh water was provided by an evaporator system, capable of distilling 12,000 gallons of fresh water per day. The system was powered by a generator on the island. Water was stored in tanks on the surface and below the ground. It is not known whether catchment water was also used, but it is reasonable to assume that it was. In more recent years, the U.S. Coast Guard has obtained water through catchment and distillation. The existing catchment system takes runoff from the Signal Power building, barracks and recreational court and pumps it into one of eight raw water tanks. Total water tank capacity on the island is 150,000 gallons (five at 20,000, five at 10,000). Water is treated by sand filter and chlorination, and stored in the tanks. Potable water is also produced by a distillation system, based on the principle of waste heat recovery. A HJ120 evaporator, using heat from generator engine cooling water, distills 900 gallons of water per day. The Coast Guard estimates normal consumption of fresh water at approximately 25 gallons/man per day, and the usual complement of men on the island is 20. Salt water is used on the island where possible to reduce potable water consumption (i.e. toilet system, outside fire control).

It should be noted that there appears to be considerable difference of opinion among personnel that have been stationed at Tern Island, or visit the site regularly, regarding the adequacy of the existing water supply. Certainly whether or not the potable water supply limits the number of personnel on the island will vary considerably with rainfall patterns and the condition of the distillation equipment, catchment facilities or storage tanks. A detailed assessment of future water needs should include a historical review of water supply and demand.

Environmental Consequences

The impact of various management options on the hydrology of Tern Island is probably of little long term significance in view of the fact that there is no anticipated demand for groundwater. Demand for potable water from catchment and distillation will have a direct effect on the types and magnitude of activities that are feasible on Tern Island in the future. Water supply will also affect decisions regarding which types of use are compatible with one another in a long range management scheme.

It should be noted that this evaluation of management alternatives does not seriously consider any options or combination of options that will result in the long term residence of a significantly greater number of people than are now accomodated on the island. Environmental considerations are considered to be overriding factors that require this form of limitation. With this in mind, one can conclude that domestic water needs of residents on the island, under any of the alternatives, will not exceed the present catchment, storage and distillation capability. However, non-domestic needs for the support of fishing or research facilities (including vessels) may greatly increase fresh water demand.

The principle demands for potable water in the future under the various management options include domestic use by residents (drinking, bathing), water supply to vessels using Tern Island, ice production and processing of catch. It is possible to increase storage capability through construction of additional tanks. When the station was rehabilitated in 1972, additional water for the construction was provided by temporary rubberized bladder storage, capable of storing 40,000 gallons of water. FWS also negotiated unsuccessfully with the Coast Guard to steam clean the five existing 27,000 gallon capacity diesel fuel tanks to increase water storage capability. It is questionable whether catchment capability could be improved significantly without construction of additional facilities. Paving of portions of the runway at the west end could make possible some additional catchment without compromising use of the airfield, but it may be prohibitively expensive. Employment of distillation equipment with larger capability would eliminate the potable water supply problem, as evidenced by facilities used when the island was used as a Naval Air station. This, in turn, would involve major expense for new equipment and additional provisions for shipment and storage of a significantly greater supply of fuel oil to power the generators.

Water supply is obviously of no significance to the abandonment alternative, although it should be noted that rapid deterioration of storage facilities will soon make the island of little use to vessels in distress. The outpost station option will not require use of the 250KW generators, as smaller generators or alternative power sources (wind, solar) will prove more economical. If the existing generators are not used, the presently installed distillation equipment will not function. Unless smaller distillation units were installed with other powered generation equipment, all necessary water must come from catchment. Power will need to be sufficient to run the water transfer pumps or the system will need modification. A decision regarding use of the 250KW generators, and in turn the distillation system, for the mid-level research option will depend in part on whether or not the island is shared for other uses. It is not anticipated that any of the research options, or the education/

recreation option will require fresh water supply beyond the existing capability.

Fishery station options that involve frequent resupply of fresh water to vessels will need additional water, the exact amount dependent upon the number of boats serviced. Additionally, ice production requirements are an unknown that will vary radically with the 1) number of boats, 2)brining and refrigerated hold capability of boats, 3) availability of chill boxes on island, 4) frequency of air shipment, and other factors. A typical mid-range vessel fishing for ahi and bottom-fish may use between 3,000-9,000 lbs. of ice for a week's fishing. To produce this ice, approximately 400-1,100 gallons of water would be required. Additional ice may be required for on-island storage for air shipment. Other fisheries (albacore, aku) depend more on brine solutions for on-vessel storage, so ice demand would be less.

Ice requirements could be reduced significantly by various methods. It may be necessary to use boats with only refrigerated holds or brining capability. On-island storage could be accomplished by brining or chill boxes, but this would reduce the time that fresh fish could be stored, and thereby increase the need for more frequent air shipment. It has been suggested that empty aircraft enroute to Tern Island could also bring large ice loads with them. Another concept that would reduce the impact of fish storage needs on fresh water supply would be to use salt water ice. This would require greater power demand to produce colder temperatures, but the ice would last longer and would not harm fish as much as fresh water ice when it thaws. Finally, the ice requirement would be further reduced by shifting emphasis to a frozen fish industry. If a mother ship was not used, additional freezer facilities, including possibly a flash freezing unit, would be required on Tern Island. This would significantly increase the power demand, but lower the water requirement. It is uncertain how much fresh water would be required for potential processing of catch on island.

It is apparent from this discussion that anticipated demand for fresh water, particularly that associated with fishery station options, is highly flexible. Although it is clear that demand could easily exceed presently available supply and production capability, it is also clear that supply could be increased by improved catchment or distillation, and that demand could be reduced through alternative techniques (freezing, brining, chill storage, etc.). It will be important to rigorously evaluate the fresh water demands (including cumulative demands) associated with various options, but it is premature in the absence of more descriptive data on the fishery options to carry the discussion further at this time.

WATER QUALITY

Affected Environment

Water quality for a particular body of water is determined by measuring its physical, chemical and biological characteristics. Standards that may be established to protect water quality reflect the minimum acceptable levels based upon these and other criteria (Ref. 60). The condition of Hawaiian coastal waters is directly affected by human activities on the land and ocean, although it may often be difficult to precisely pinpoint the source of water pollution. As might be expected, those inshore areas of the State subject to the least human use generally exhibit pristine or near pristine water quality characteristics. Of the Northwestern Hawaiian Islands, permanent manned installations are found only on Midway Islands, Kure Atoll and Tern Island. Unfortunately, the least amount of pertinent water quality data are available for Tern Island.

Some important parameters of water quality include salinity, temperature, dissolved oxygen, bacterial levels, light extinction coefficients, turbidity, nutrient concentrations and chlorophyll a. Existing water quality standards in Hawaii are based on a simple classification system, including two inland categories and three coastal water categories. These standards lack direct relevance to ecological criteria and don't readily account for natural variability. They are ambiguously defined and difficult to enforce (Ref. 60). Under authority of the Federal Water Pollution Control Act amendments of 1972, specifically Section 208, and the State Environmental Quality Law, the State Department of Health has been given responsibility to develop and enforce improved water quality standards. Proposed standards have been published and are now in the review process. The program began with classification of the State's waters, and determination of appropriate uses of waters in each category. Proposed standards relate to water and bottom types. Proposed uses include 1) pristine-preservation, 2) limited consumptive, 3) exploitive consumptive, and 3) construct-alter. Some factors considered in the preliminary assignment of Hawaiian waters to these use categories include value to recreation, fish and wildlife, critical habitats, unique ecological values, fishing, public health, aesthetics, etc.

In the proposed water quality standards, only one inland water body was identified in the Northwestern Hawaiian Islands: the wetland at Laysan Island was recommended for pristine-preservation use. Both lava rock shorelines and sandy beaches in the Northwestern Hawaiian Islands were also classed in the pristine-preservation use category. Offshore reef flats and protected coral communities at Kure Atoll, Midway Islands, Pear and Hermes atoll, Lisianski Island, Laysan Island, Maro Reef and French Frigate Shoals were also placed in the pristine-preservation use category. The significance of these recommendations if accepted as official water quality standards relates to the determination of allowable human use in the future. The pristine-preservation category is defined to include passive human use without intervention or alteration, allowing perpetuation and preservation of waters in a most natural state (i.e. non-consumptive research, education, enjoyment).

It was noted in the discussion of the pristine-preservation category for offshore reef flats that this would include "areas proposed or designated as refuges, reserves, preserves; small scale non-degrading fishing allowed except where more restrictive controls on fishing (or collecting) specified by other agencies." The "soft bottom community" was classed in the "limited consumptive" allowable use category. It should also be noted that the proposed standards include some specific reference to certain identified actions that degrade water quality. For example, the standard for oil and petroleum products specifies that "no oil or petroleum products shall be discharged into marine waters that... can be detected as a visible film sheen or discoloration of the surface, or by odor...or can cause tainting of fish or invertebrates or other biological damage."

The principal sources of pollution within FFS stem from activities on Tern Island and from vessels within or nearby the shoals. Degradation of nearshore water quality in the Tern Island area began with the reconstruction of the island in 1942, as a result of extensive dredging and deposition of dredged material behind steel bulkheads to recreate the island. Surely this activity created major increase in turbidity above ambient levels, with subsequent adverse effects on marine biota. The long term adverse impact of the dredging project through degradation of water quality will never be known in the absence of previous baseline data, but it was very likely of major significance. Resuspension of bottom sediments during dredging lowers dissolved oxygen levels. Resuspension of nutrients trapped in bottom sediments will increase primary productivity, although continued circulation will mitigate this impact that could be more serious within embayments or harbors characterized by low circulation. Other biological impacts of dredging are addressed in subsequent sections of this report.

Other activities that have contributed to some degree to lowered water quality near Tern Island include the disposal of sewage and other liquid waste (i.e. waste oil). The C.G. sewage disposal system is a self-contained secondary treatment plant. Galley wastes and salt water sanitary flush toilet wastes constitute about 45% of the plant influent, estimated at approximately 75 gal./man/day. (Ref.47). Multiple individual aeration-clarifier tank units (half in operation, half in standby) process the wastes, with a minimum BOD reduction of 85%. A 1978 National Pollution Discharge Elimination System (NPDES) permit application to the Environmental Protection Agency lists the average outflow at 0.002 million gallons per day. The existing disposal is by pipe below the sand on the south side of the island. The pipe extends 170' from the treatment plant, running through precast concrete rings over the bottom below the mean low water. This outfall was constructed under a 1974 Department of the Army permit issued pursuant to Section 10 of the River and Harbor Act of 1899.

It is our understanding that the Coast Guard disposes of other liquid wastes, such as waste oil from the on-island generators, by percolation into the ground or by incineration. Water pollution also occurs adjacent to the station as a result of leakage and spillage of diesel fuel oil. One of the five 27,000 gallon fuel storage tanks is presently not in use because the foundation of the structure is settling, creating a risk of future leakage. Fuel spillage occurs primarily during the transfer of fuel supplies to the island, but to date there have been no serious spillage incidents associated with this operation.

Bunker crude oil has been detected on beaches of sandy islets, including Tern Island on several occasions, particularly in recent years. The sources of the oil have not been determined. Impacts of this oil on aquatic and terrestrial fauna are discussed in subsequent sections. Only one major spill of crude oil has been recorded in the Northwestern Hawaiian Islands. On January 17, 1977, the Liberian registered tanker IRENES CHALLENGE broke in half 50 miles due north of Lisianski Island (200 miles southeast of Midway Islands). The leakage of 4.5-5.5 million gallons of light crude oil produced an oil slick 50 miles long and 10 miles wide, but gradually dissipated over the next week. Fortunately, drifting slick bypassed the Northwestern Hawaiian Islands, so adverse impacts on marine fauna were believed to be minimal. However, as a result of this event and the threat of future similar accidents, the Coast Guard issued a Public Notice (No. 14-78-01) in January, 1978, proposing designation of an "Area to be Avoided." This area would include waters within 100 miles north of the Northwestern Hawaiian Islands (and shoals) and 50 miles south, east and west of the islands. The notice would discourage but not prohibit vessels over 1,000 tons from entering this area.

Environmental Consequences

The adverse impacts associated with various management options for Tern Island will be directly dependent upon the number of people accomodated on the island, the type of activities on the island and the incidence of vessel pollution in the area. Nearshore water quality degradation as a result of the abandonment option would be limited to the effect of gradually deteriorating structures and other facilities. Presumably all existing fuel or gas stores on the island would be depleted or removed, rather than left to pollute nearshore waters. Water quality effects under the outpost station option will depend upon what system is utilized to process and discharge sewage and other liquid waste. It may be uneconomical to run the treatment plant for a minimum crew on island, particularly because the system would involve power demands that were not justified by its use. Alternatively, a self-contained waste processing system (i.e. Clivus-multrum) could be installed to meet the needs of the skeleton crew. Other chemical toilet systems would still require off island disposal of some kind.

Operation of the mid-level research station, particularly if shared with other uses, would appear to justify retention of the existing sewage treatment system. Reduced occupancy of the facility during winter months may justify a temporary shift to another system. For any of the options, or combination of options, involving full occupancy of the station (i.e. full level research, inshore fishing, others combined) the existing system should be kept in operating condition. It should be noted that interim selection of a low occupancy alternative should incorporate provisions for maintenance of the treatment system in a condition that will facilitate easy restoration into operation. Coast Guard experience at the station indicates that operation of the treatment system requires frequent monitoring of the system: chlorine residual (daily), dissolved oxygen (daily), settlable solids (2-3 times per week).

Requirements for acceptable sanitation devices in all vessels can be used as an effective enforcement tool to protect inshore waters at FFS from adverse impacts of sewage pollution. Enforcement of regulations to prevent discharge of any sewage, treated or otherwise, will probably be more difficult as it is unlikely that pump-out facilities will be constructed on island. Even if they were built, collected sewage would have to be discharged through the Tern Island system. Depending upon the number of boats involved, it would be easy to overload a system designed to accomodate only 20 men on a continued basis. The obvious alternative is to contain sewage in vessels, and dump it at sea, outside refuge waters. This would be most feasible for the offshore fishery options (trap, aku, ahi, albacore, precious coral).

Regulations to prevent any wasting of bilge oil or other contaminants into FFS waters should be rigorously enforced, regardless of the management option or options selected. Unfortunately, enforcement would be virtually impossible to accomplish unless the vessels were willing to police themselves rigorously. The threat of inadvertent oil spills is obviously greatest in the vicinity of Tern Island when fuel oil is transferred to the station. The Coast Guard accomplishes this task by barging fuel to the island, with apparently good results. Whether or not the long period of experience that the CG has in this operation is critical to successful transfer remains to be seen if other boats attempt the operation. An alternative method employed at Kure Atoll involves a permanent fuel line from the shore that reaches to a mooring buoy adjacent to the island. If a management option is chosen that will require substantially greater demand for fuel oil storage (i.e. aku, ahi, albacore, trap fisheries) then perhaps a more foolproof system of fuel transfer will be necessary to protect the water quality of inshore areas.

The incidence of vessel pollution through at-sea disposal of sewage and bilge oil is uncertain for the FFS, and the historical effect of the activity is equally unclear. It is clear, however, that many of the boats regularly entering the area (buoytenders, fishing boats, research vessels) have regularly discharged both untreated sewage and waste oil in conflict with refuge regulations. The federal government has regulatory authority over the discharge of sewage and bilge oil from vessels, implemented by the Coast Guard under authority of Sections 312 and 311 respectively of the Federal Water Pollution Control Act amendments of 1972. Under Section 312, all vessels must have certified sanitation devices by January 30, 1980. The State may also apply to the Environmental Portection Agency for authority to issue regulations completely prohibiting discharge of any sewage, treated or otherwise, within designated waters to be protected. However, this could not be effected unless adequate facilities for sanitary removal and treatment of sewage were reasonably available in the area to be affected.

Additional dredging of the access channel and turning basin area does not appear necessary to accomodate mid-range vessels. During the brief marine survey in March, 1979, it was not apparent that the original 20 feet deep dredged channel had been appreciably reduced in depth by transport of sandy materials from adjacent areas. The need for dredging should be adequately assessed through field survey as part of the continuing evaluation of various management alternatives. It is unlikely that the adverse effects of extensive dredging on marine ecology would be considered compatible with refuge management objectives.

It is uncertain at this time what effect the proposed water quality standards will have upon decisions regarding selection of management options for Tern Island. If the standards are approved as proposed, and rigorously enforced, it would appear that identified "unsuitability" of pristine-preservation to commercial uses would limit the selection of management options.

AIR QUALITY

Affected Environment

Climatic data pertinent to discussion of air quality at Tern Island have been discussed previously(Section7c). The remoteness of the site makes the air quality characteristics almost entirely dependent upon local phenomena. In addition, virtually constant winds mitigate the effects of any locally produced air pollution. The primary existing human sources of air pollution include exhaust from boats (buoytenders, fishing boats, research vessels, skiffs, etc.), generator exhaust, intermittent open burning, incinerator smoke and coralline dust or sand stirred up by vehicle movement or aircraft. The dust situation is most serious when aircraft take off and land on the island, although this impact has diminished significantly since C-130 and DC-3 flights ceased in 1977. Natural events that impact air quality include wind-borne dust and sand during windy weather and the odors associated with decaying organic matter or simply the presence of wildlife. The natural effects on air quality vary considerably with weather and seasonal behavior patterns in wildlife. Periodic storms distribute organic debris over the island that may become offensive as it rots. Natural potentially offensive odors associated with the seabird colonies are likely to be most significant shortly after the peak egg laying period, when most birds are in the colony and infertile or abandoned eggs are rotting in the sun. This situation is affected significantly by intentional efforts at control of Sooty Tern populations on the island. Although there is no apparent record of odor problems associated with this activity, it is likely that the intentional destruction of thousands of eggs over a short period of time, at the upwind end of the island, produced temporarily offensive results for Coast Guard residents.

The incinerator installed at Tern Island during the 1972 rehabilitation of Coast Guard facilities is designed with burners to operate on Number 2 diesel fuel. Although the specifications for the equipment call for an odorless and smokeless unit for incineration of burnable trash, it is doubtful that it fully meets those criteria. Other equipment that temporarily elevate hydrocarbon levels include the Caterpillar D353 generators (one run at a time), the motor vehicles (jeep and pickup truck) and the John Deere tractor. Additional air pollution is associated with infrequent open burning.

Environmental Consequences

The impacts to existing air quality, and the significance of those impacts to human use, would vary considerably between different management options. The abandonment option would lead to no additional human-caused air pollution, excepting that which may occur during a clean-up operation. It is anticipated that this might involve extensive open burning to limit the amount of solid waste that would have to be buried or removed from the island. Any of the alternatives involving human occupation of the island would be affected by both natural and man-induced impacts to ambient air quality. Operation of large aircraft on the runway would result in the most major man-induced change in existing conditions, but the effect would be brief. It is not anticipated that island-produced hydrocarbons from combustion engines would be increased appreciably from existing conditions under any of the alternatives being considered. Any alternatives that involved significantly reduced number of personnel on the island, particularly if the existing generator facility was not used, would reduce the hydrocarbon emissions.

Any fishing station option that involved storage or processing of catch has the potential of creating offensive odors. The significance of the impact would depend upon whether or not a fishing station option was shared with a research option or other non-fishing activities. The adverse impacts would also vary with the location on the island at which the activity took place. Also natural odors (decaying fish and dead birds, fecal material) in the seabird colonies and the odors associated with egg destruction programs will be considered offensive by some residents or visitors to the island. Presumably egg control will be unnecessary for those alternatives that don't require air shipment of fish by large aircraft.

It should also be noted that researchers have expressed interest in using Tern Island as a control sampling site for studies of air quality in the Pacific Ocean. Highly sensitive equipment used in this experimentation has proven to be non-functional at Johnston Island due to wind borne air pollution originating on Oahu and other main islands. Some types of on-island activities at Tern Island could preclude use of the site for this purpose.

NOISE QUALITY

Affected Enviornment:

Ambient noise levels are the combined effect of natural and man-induced phenomena. At Tern Island, significant natural contribution to ambient noise results from the vocalizations of wildlife (principally nesting birds) and climatic factors (i.e. wind, rain, wave action, etc.). The intensity of sound levels has surely increased within the last decade as a result of the dramatic increase in numbers of nesting Sooty Terns (Sterna fuscata). However, Coast Guard living quarters are for the most part well isolated from natural sounds.

Man-induced noise on Tern Island has been the result of combustion engines (including generators, pumps, boat motors, vehicles, aircraft). In the past, the landing and takeoff of large aircarft has probably caused the most significant, although brief, increase over ambient noise levels. Aircraft movement also stimulates a marked increase in natural sounds of birds startled into flight from their nests. Problems with aircraft disturbing wildlife in the refuge, including endangered species, has prompted the FWS in recent years to exercise its authority to enforce a 2,000 ft. minimum overflight regulation for fixed wing aircraft and helicopters. There is, however, some concern that this regulation is not rigorously enforced. Periodic patrol flights by Coast Guard aircraft may descend below this level for surveillance reasons, but it is not recommended unless necessary because of the disturbing effect on wildlife.

Enviornmental Consequences:

Anticipated noise levels associated with human use of Tern Island will vary considerably with different management options. Those individual options or combination of options that involve operation of the facility at full capacity will result in a noise environment similar to the Coast

Guard station. Added to this noise level may be the sound associated with processing equipment, additional vehicles for transport of fish, and possibly equipment to maintain and repair the seawall. Construction of additional facilities will obviously result in temporarily elevated noise levels as well. Resumption of flights into the island by large aircraft will also occur for implementation of options involving air shipment of fresh fishery products. Conversion of power demand to wind and solar equipment would significantly lower noise levels by reducing or eliminating the need for generators powered by combustion engines.

The frequency of boat movement, with the associated disturbing effects on wildlife of boat motors, is anticipated to increase within nearshore waters of FFS if greater numbers of fishermen or researchers visit these areas. Noise associated with boats participating in offshore fisheries will affect both wildlife and human residents on Tern Island if boats regularly transit to and from the island for transfer of men, cargo and fuel.

AQUATIC BIOTA

(Excluding cetaceans and endangered species)

AFFECTED ENVIRONMENT

With some notable exceptions, the fish and macro invertebrate fauna of the NWHI are generally identical in species composition to that of the high, southeastern islands. However, reef community structure differs considerably between the northwestern and southeastern limits of the archipelago because of differing environmental (physical, biological, and man-induced) factors. For example, water temperatures are lower in the northern islands and fishing pressure is dramatically reduced. The present Tripartite Cooperative Agreement for surveying NWHI reef communities involves underwater census and fishing programs. The results of initial surveys at Kure Atoll and Midway Islands indicate an extraordinary abundance of large fish predators (Caranx spp., Epinephelus quernus) as well as notably large sizes of other species (Bodianus bilunulatus, Coris spp., Kuhlia sandivicensis, Myripristis spp.). (NMFS, CROMWELL Cruise Report 77-02-75 Part V) In addition, Midway Islands and Kure Atoll have been found to support a lush growth of benthic algae on lagoon patch reefs (Ibid). Cooler water temperatures seemingly provide better growth conditions for this species of algae. The obvious, gross differences in physical, biological and man-induced factors are certain to be accompanied by a myriad of subtle distinctions essential to the survival of the NWHI reef ecosystems.

Ages of interaction between species and habitat on the NWHI reef stage have developed finely tuned strategies of energy transmission from primary producers to tertiary consumers and nutrient recyclers. In spite of a common cast of characters between the NWHI and the high islands, the respective roles that a species plays may differ considerably. A key species is defined as one that contributes significantly to maintaining the balance of a reef community (and whose decimation results in ecological pertubation). Because of the differing community structure between the NWHI and the high islands, a fish or invertebrate might perform as a key species in one environment and not in the other.

The coral reefs of FFS have remained largely unexplored until recently. Fish surveys conducted in 1976 at East Island (NMFS Cruise Report 76-04-71) recorded 29 species -- of which Scarus perspicillatus, Kyphosus cinerascens and Mulloidicthys samoensis were the most frequently encountered. Thirteen specific survey stations were recently investigated at FFS (HSFG F-17-R-2) at a wide range of nearshore areas. The most frequently encountered species (in order of abundance) at seven transect stations were : Spratelloides delicatulus, Kyphosus cinerascens, Scarus perspicillatus, Naso unicornis, Mulloidichthys samoensis, Acanthurus triostegus, Caranx melampygus, Thalassoma duperreyi, Acanthurus mata, and A. nigroris. Kyphosus cinerascens ranked highest in estimated biomass, followed by Scarus perspicillatus, Naso unicornis, and Mulloidichthys samoensis. Acanthurus triostegus made a more significant contribution at other stations surveyed by quadrant methods (HSFG F-17-R-2).

Although small isolated colonies of the coral genus Acropora have been recorded in Hawaiian waters, it was generally believed that the genus was effectively confined in distribution to the warm waters of Indo-Pacific atolls. The recent discovery of extensive beds of Acropora cytherea (or A. vallida) by Drs. Grigg and Taylor at FFS was entirely unexpected. A very large bed (hundreds of thousands of individuals) exists in shallow water (depth 20-50') just north of La Perouse Pinnacle. An extensive survey is needed to determine the size of the bed and if other beds occur at FFS. The historical status of the *Acropora* bed will be determined by core sampling during field studies in June, 1979. The presence of *Acropora* provides a habitat for a variety of other organisms which are either uncommon or absent in the high islands. The chevron butterfly fish (*Chaetodon trifascialis*) occurs abundantly in the FFS *Acropora* beds. Although this species is common on the *Acropora*-rich reefs of Indo-Pacific atolls, it has never been reported in the high isalnds (other than as a few juvenile stages). Other fish species not commonly found in the high islands, but often recorded at FFS, include the telescope wrasse (*Epibulus insidiator*) and the masked angel fish (*Geniacanthys personatus*). Taylor (pers. comm.) reports that the latter species does occur in the high islands at considerable depth (400' for males and 150' for females) whereas at Disappearing Island in FFS, both males and females have been observed at 60'. It is likely that other associated fish, invertebrates and algae may be identified as members of the FFS *Acropora* community. FFS *Acropora* beds present one of the most unique reef communities in the Hawaiian Islands. It should be emphasized that *Acropora* is a structurally fragile coral and also that the beds are in shallow water. Therefore, they may be very susceptible to damage resulting from anchorage of vessels and deployment of traps.

Notes of field observations made by Ron S. Nolan in the vicinity of Tern Island on 15 March 1979 are included here in abbreviated form:

Dredged Channel Between Island and Fringing Reef

Depth, generally 20 feet. However, one massive, consolidated coral pinnacle, approximately mid-island, reaches the surface and is a hazard to navigation. We spent approximately 15 minutes snorkeling around the pinnacle and observed several common species of Hawaiian reef fishes, including many large table bass, Bodianus bilunulatus. The coral boulders were encrusted with filimentous algae and Porites lobata. Coral cover, however, was not extensive.

Many Chaetodon auriga and Abudefduf sordidus were noted to be in abundance. In one small opening several lobsters (approximately six large individuals) were observed. The current direction was offshore towards the Coast Guard station and estimated at 1-2 knots.

Two large species of sea cucumbers were observed in the area. One apparently was Actinopyga (similar to mauritiana) and Bodhadischia (similar to marmoratus). However, we were unable to collect specimens because of the marine life conservation status of the area. Many sea cucumbers were seen throughout the area, mostly large (apparently) thick-walled individuals.

Area Immediately Surrounding the Dock

This region was shallow in depth (4-6 feet). According to Coast Guard residents, the lagoonward beach demonstrates seasonal sand movement, especially during winter periods when considerable erosion occurs.

The marine life in the vicinity of the dock is sparse (only a school of unidentified juvenile fish were observed). The lack of hard substrate in the dredged areas is reflected in the absence of living corals and reef fishes.

Lagoonward of Dock in Channel

A strong lagoonward current enabled us to drift out the channel and make observations while snorkeling. The depth in the central area of the channel is about 18-20 feet. The channel slopes gradually upwards to a consolidated coral wall of boulders and formations nearly reaching the surface.

The only fish observed were in the rock and coral areas. Most living coral was Porites lobata which encrusted about 50% of the hard substrate. Small heads of Pocillopora were also noted. Many species and individuals of fish were seen in areas of cover - these consisted primarily of butterfly fish and surgeon fish. Fish species that were abundant and of exceptionally large size were the table bass (Bodianus bilunulatus), ulua (Caranx melampygus) and uhu (Scarus perspillatus). Many individuals of the unicorn fish (Naso unicornis) were noted. No sharks or lobster were observed. Sea cucumbers occurred in the channel and also between coral formations. The channel bottom was of heavy granular consistency and did not appear to be silting in.

Observations Around the Most Lagoonward Buoy

Water depth ranged from 6-20 feet from sand channels to coral reefs. Live coral cover was estimated to be more than 30-40%. The most frequently encountered species was Porites lobata. However, other species of Pocillopora were occasionally observed.

The finger coral Porites compressa was not notably abundant. Many large carnivores were observed; for example, Caranx melampygus and the table bass, Bodianus bilunulatus. Heads of Pocillopora meandrina and associated hawkfish were noted. Large parrot fish were in abundance (including Scarus sordidus and Scarus perspillatus).

General Observations of Marine Life

Invertebrates: Sea cucumbers were abundant and at least four morphologically distinct types were observed. Historically a beche-de-mer fishery occured at the French Frigate Shoals.

Dredging of the reef has resulted in the removal of hard substrates and dredged areas have not been re-colonized by corals due to lack of hard substrate. Future dredging of the area would only affect the environment in terms of disposal of dredge tailings and temporary turbidity.

Although the fish fauna in the region was not especially diverse or rich in abundance as compared with the pristine reefs off Hawaii Island, (for example Ke-ahole Point), the size of certain individual fish was notable. For example, ulua, parrotfish, unicorn fish and table bass were a much larger size than those on Island of Hawaii reefs exposed to fishing pressure. Conversations with anglers at the Coast Guard Station indicate that they annually take many hundreds of large ulua within the vicinity of the Coast Guard Station. Kawa kawa and mahi mahi occasionally are captured.

Shorecasting for Caranx melampygus is extremely productive with fish averaging 10-20 pounds. Large ulua (Caranx spp.) were only occasionally observed. However, these species apparently constituted at least half of the angler's catch and may have been abundant at other times and places.

The Coast Guardmen at Tern Island also frequently capture large gray reef sharks and tiger sharks. During our brief visit we observed no sharks.

Our observations in Tern Island waters were limited to only one hour. In summary, the fauna is not especially diverse, however exceptionally large individuals of Hawaiian game fishes do occur in abundance. No rare or endangered species of fishes or invertebrates were observed.

ENVIRONMENTAL CONSEQUENCES

The abandonment option for Tern Island may involve intense, short-term activities associated with the removal of structures. As a result, some temporary impacts associated with removal of facilities and disposal of solid waste can be expected. Also, some fuel leakage may occur during transfer from storage tanks. Long term lack of enforcement and surveillance will lead to a greater incidence of illegal exploitation of refuge resources. Game fish stocks might be decimated leading to serious repercussions throughout the food chain. Sharks might be sought for jaw trophies; jacks and other game fish for food. Skiffs and other vessels anchoring over the Acropora beds would lead to physical damage through chain chafe and dragging anchors. The impacts of oil and sewage pollution would be proportional to the amount of illegal activity. The worst case would be grounding of a large vessel and fuel dispersion without reporting to Honolulu agencies who might attempt mitigation, containment or cleanup.

If the outpost facility is established, no major impacts to fish or other reef life are anticipated if Acropora beds are protected from indiscriminant anchoring and if recreational angling is regulated or prohibited. Support of continuing research effort would encourage additional surveys of FFS to insure that unique aquatic systems are mapped and protected. As the intensity of research activity increases (i.e. mid- or full level facility), increased demand for gasoline and diesel fuel will increase dangers of petro-pollution. The effects of petroleum discharge on coral reef systems depends upon several factors including the type of fuel, duration of exposure, kind and age of organisms. Dr. Loya of Israel is addressing the impact of oil pollution on Red Sea reefs and will contribute a chapter on the subject in a forthcoming book on coral reef pollution edited by Dr. R. W. Grigg. At FFS the likelihood of storage tank collapse and the probability of transfer spills should be evaluated. This information should be applied to a physical model of current patterns under a variety of weather conditions to develop dispersal projections. Once the models have been developed, the degree of environmental destruction associated with the collapse of a storage tank can be projected.

As the number of scientists and support personnel increase, restrictions should be placed on diving and collection activities which might lead to ecosystem perturbation (e.g. destructive means of collecting shells, fish poison stations).

It is possible that heavy inshore fishing pressure directed towards a few top carnivore species at FFS might significantly reduce their population, especially if highly efficient gill nets are utilized. Predators are considered by several ecologists to be "key" species in a reef community. For example, heavy natural predation pressure may prevent a species of prey from excluding an ecologically similar species in that population levels never achieve a threshold level where competitive exclusion occurs. Prior to opening the FFS to an inshore fishery, a thorough analysis of standing stocks, and predicted sustained yields should be used to project the effects of fishing on other levels of the food web. A monitoring program should be instigated to compare actual catch per unit effort with that predicted by the model. Also, the secondary impacts of coral damage due to entanglement with nets and dragging of anchors should also be considered.

One of the objectives of the Tripartite Cooperative Agreement is to assess the ciguatera toxin levels present in NWHI game fish. Only a few individuals and species have been subjected to radioimmunoassay by Dr. Y. Hokama (UH). However, the initial findings indicate that ciguatera poisoning may be present in a frequency that would lead one to seriously question the advisability of an inshore fishery at this location. Although sample sizes were low, 50% of the amberjack (Seriola dumerilii), 66% of the blue jack (Caranx melampygus) and 14% of the white ulua (Caranjoides ajax) showed high levels of toxicity (HSFG F-17-R-2). A serious study of ciguatera condition should be performed in the NWHI and FFS to determine if the economic potential of the fisheries is constrained by the marketability of the fish products.

Other fisheries that may involve direct depletion of marine species within refuge waters are the sport fishery, aquarium fishery, and potentially the harvest of bait for aku fishing. Depending upon the intensity of the sport fishing effort, decimation of individual gamefish stocks may occur, with somewhat unpredictable impacts on marine ecology. Reef damage will result from anchoring of boats, but this is expected to be minimal by comparison to a commercial inshore fishery. Much of the potential adverse effects of a sport fishery can be mitigated by directing the activity to waters outside refuge boundaries.

The principle adverse impact associated with the aquarium fishery is the possibility that uncommon or rare species would be depleted for their commercial value. Selective harvest could have long-term adverse impacts on reef ecology. Unique marine communities (i.e. Acropora beds) would be attractive to this fishery and subjected to locally intensive disturbance for fish and invertebrates, including coral. It is unlikely that fence net collection techniques would have a major impact on FFS reefs, but the remoteness of the area and lack of enforcement presence would encourage the use of chemicals that might adversely affect other species.

If the aku fishery exploits bait stocks in the refuge waters, impacts to the reef environment are expected as a result of anchor dragging and net damage. Also the documented unpredictability of bait yield in this area raises the obvious unanswered question regarding impacts of bait harvest on energy transfer through the food web.

Each of the fishery alternatives involving fuel support facilities at Tern Island would increase the risk of fuel pollution during transfer and as a result of on-island storage needs. The risk of sudden major spills due to grounding on the reef would increase porportionately to the frequency of boat traffic (Section 7e). The need for additional channel or harbor dredging is dependent upon the size of vessels that would travel to and from Tern Island the the requirements for docking facilities. If dredging proved to be necessary, primary impacts on aquatic biota include 1) direct loss of benthic habitat; 2) sedimentation in spoil disposal sites (smothering additional benthic species and habitat), 3) localized impact on water column species due to increased suspended sediment (i.e. clogging of gills, reduced primary productivity due to decreased light penetration). Rare Acropora colonies and other reef areas, could be adversely affected by sedimentation.

Also, depending upon presently unknown navigation requirements, vessels involved in any of the fishery or research management options will need to anchor at various locations within or adjacent to refuge boundaries. Some impacts to reefs is anticipated, perhaps including rare Acropora colonies. These impacts could be mitigated by designation of specific anchoring sites and by establishing mooring buoys in certain areas.

The offshore trap fishery could result in at least one unique impact in the vicinity of Tern Island. If crustaceans are processed on island, waste disposal requirements may be substantial. It is likely that offshore disposal may be required in view of the refuge status of adjacent waters. Although such wastes might attract reef fish in abnormally large numbers, this impact would probably be viewed as an unnatural alteration of a functioning ecosystem. Waste disposal would also adversely affect research studies of reef species and could pose serious safety considerations when shark concentrations increased.

Implementation of the educational/recreational option is expected to have only minimal adverse impact on aquatic biota, assuming this involves non-consumptive use. Some inadvertent damage will occur from anchoring of boats, trash and sewage disposal and repetitive disturbance in previously unused areas. Use of SCUBA will increase the range, intensity and duration of disturbance caused by human presence.

CETACEANS

AFFECTED ENVIRONMENT

Cetaceans are common within the NWHI. Shallenberger (Ref. 153) reports 19 species, three of which are common in shallow, inshore waters. All three have been reported from FFS.

Humpback whales (Megaptera novaeangliae) are common winter residents of the Hawaiian Islands (Ref. 150). The first humpback whales arrive each year in the main islands in early November and the population reaches a peak in late February (Refs. 96, 151). The distribution of humpbacks in Hawaiian waters is well documented, but their migration routes are not. It has been theorized that humpbacks may migrate from Alaskan waters by following the northwestern islands until they reach the main islands where they calve, although there are few data to support this hypothesis (Ref. 151). Although humpback whales have been seen near FFS, they are probably uncommon visitors in the area.

Bottlenose dolphins (Tursiops truncatus) are very common throughout the Hawaiian archipelago and are frequently seen near FFS. Tursiops are commonly found in shallow inshore waters, over offshore banks and in deep channels between islands. It is not uncommon to see them in water of less than ten fathoms in FFS. Bottlenose dolphins feed on a wide variety of organisms ranging from numerous species of invertebrates to large pelagic fishes such as yellowfin tuna and mahi mahi. Bottlenose dolphins have also been known to frequently rob fishermen of their bait or their catch, sometimes to the point of causing the fishermen financial hardship.

Spinner dolphins (Stenella longirostris) are extremely common throughout the Hawaiian Islands. In the NWHI there is a population at each major lagoon or reef (Ref. 153). Spinner dolphins typically spend the daylight hours in the sheltered waters of lagoons and bays, going offshore in the late afternoon and evening to feed (Ref.131). Spinner dolphins typically feed on small mesopelagic fish and meso- and epipelagic squid. Several species of myctophid fishes and two species of Abralid squid are common in the diet of Hawaiian spinners.

ENVIRONMENTAL CONSEQUENCES:

The effect of any of the alternatives on the cetaceans may take several possible forms.

Dolphins, particularly Tursiops, have been associated with fisheries of many forms. In Mexican waters, bottlenose dolphins follow shrimp trawlers eating discarded fish and shrimp that escape from the nets. In Hawaii they follow sport fishing boats that use live bait to catch marlin and take the bait before the marlin are able to. In Florida, Hawaii and elsewhere bottlenose dolphins take the fishermen's catch while it is being retrieved. In Hawaii this frequently consists of opakapaka, the most common bottomfish caught in the NWHI. If there were a concerted fishing effort near FFS it is likely that these situations would occur.

In the Eastern Tropical Pacific, spinner dolphins are frequently trapped in the nets of purse seiners. As many as 300,000 dolphins have drowned annually in these nets. With the exception of some experimental fishing, purse seining for tuna is not done in Hawaiian waters. If it were, however, to be used regularly in the NWHI, it is likely that some dolphins would drown in the nets. If gill and fence nets were to be allowed within the lagoon, the possibility also exists that dolphins might become entangled. It has occasionally happened within the main islands, but its occurrence is rare. It is unlikely that it would ever become a serious problem. It is also possible for dolphins to become hooked by fishing lines. This has happened on several occasions within the main islands. It is unlikely, however, that the problem would ever become significant.

A more serious potential problem is that of harassment, both deliberate and accidental. Continued low level harassment of humpback whales may drive them from a location (Refs. 96, 130, 151). Because there are so few humpback whales at FFS, harassment of this species will probably be insignificant. Within the main Hawaiian islands, bottlenose and spinner dolphins are quite common, even in heavily populated areas. Frequent encounters with humans do not seem to be harmful. There are, however, numerous reported incidents of dolphins being shot at by fishermen who have had their catch stolen. It is likely that a similar situation might occur were a major fishing station to develop at FFS.

TERRESTRIAL BIOTA

AFFECTED ENVIRONMENT

Flora

The natural flora of Pacific atolls is typically characterized by a small number of species, most of which are widely dispersed (Ref. 173). Yet, various atolls in different island groups illustrate marked differences in floral development. Plants that naturally colonize Pacific atolls reach the islands on the water surface, or they are blown by the wind, carried by the birds, or result from accidental or intentional introductions by man. In an investigation of atolls in the Northwestern Hawaiian Islands, Amerson (Ref. 9) determined that area of vegetation on an island was the best single predictor of the number of plant species that were present, although island elevation and distance to the nearest vegetated island also played a determining role.

The vegetation of various Northwestern Hawaiian Islands is described in detail within numerous Atoll Research Bulletins (Ref. 7, 39, 40, 41, 42, 176). Characteristically, the flora of each island reflects the patterns of human use, particularly during the present century. Amerson (Ref. 7) lists 40 species (representing 24 families) of vascular plants from FFS, based on historical records dating to 1867 and the observations of POBSP researchers between 1963-1969. Botanical records for Tern Island include 37 species, 30 of which are exotic. At the time of POBSP surveys, the flora was reported to be dominated by 18 species. An additional five exotic species of plants were added to Amerson's list during a subsequent survey by Herbst (pers. comm.).

In view of the total elimination of plants on the original Tern Island during reconstruction by the Navy in 1942, all of the existing flora stems from relatively recent natural or artificial colonization. Ten species were recorded on the island in 1953 and 22 species by 1961. The high percentage of weedy species on Tern Island provides suggestive evidence of the mode of accidental introduction, in association with equipment and supplies that have been brought to the island on numerous occasion. For example, Herbst (pers. comm.) reports that in the Hawaiian archipelago, Chloris petraea Siv. is known only from Tern Island. It is, however, widely distributed on the mainland and presumably arrived at Tern Island with Coast Guard equipment. Both Frankenia grandifolia C. & S. and Salicornia virginica L. were found on Tern Island by Herbst (pers. comm.) in 1968, but were confined in distribution to the immediate area of a pile of 55 gallon drums of aviation fuel. Simple comparison of the vascular plant list prepared by Amerson (Ref. 7) for various islands in FFS illustrates the direct relationship between intensity of human use and species diversity of exotic flora (Tern Island - 37 species, East Island - 21, Trig - 9, Whale-Skate - 8, Round - 4, Little Gin - 3, Gin - 1, Shark - 1).

Fauna

The fauna of Pacific atolls is directly linked to the location and size of the islands, and to the composition and diversity of the flora. The island fauna also reflects the dispersability of species and the historical presence of man.

Typically, the indigenous or endemic terrestrial fauna of Pacific atolls is limited to birds, land crabs, lizards and insects. Seabirds and migratory shorebirds make up the dominant avifauna, yet most species are wide ranging throughout the Pacific ocean, and in some cases, other oceans of the world. Land birds are notoriously rare on Pacific atolls, particularly on those island groups that do not have high island components (i.e. Marshalls). Laysan island is unique in it's unusually large component of endemic "land" birds, which includes three extinct species (Laysan rail, Laysan millerbird, Laysan honeycreeper) and two endangered species (Laysan duck, Laysan finch). An additional two endemic species from the Northwestern Hawaiian Islands are confined to Nihoa (Nihoa millerbird, Nihoa finch). No other endemic land birds are known from other atolls in the archipelago, including FFS. However, 27 Nihoa finches were released on Tern Island in March, 1967. Although some individuals bred successfully on the island for a few years, there are apparently no records of the species on the island in the last five years. Other land birds that have been recorded at FFS included introduced species that did not survive long (domestic chicken, ring-necked pheasant) and occasional visitors (mockingbird, short-eared owl).

The principal endemic land reptiles on Pacific atolls are skinks and geckos. Some species not naturally occurring on certain islands have also been distributed inadvertently around the Pacific by man. The only lizard known from FFS is the Mourning gecko (Lepidodactylus lugubris), presumably introduced in recent years during the shipment of equipment to Tern Island. In contrast to the situation on many central Pacific atolls, land crabs, including the widespread coconut crab (Birgus latro), are conspicuously absent in the Hawaiian archipelago. The numbers of endemic terrestrial arthropods are greatest on Nihoa and Necker (Ref. 25).

Radical changes to flora of the more northwestern atolls is thought to be responsible for the small number of endemic insects. Beardsley (Ref. 25) recorded 52 species of terrestrial arthropods on islands of FFS, including 25 species that had not been recorded previously. Many of the new introductions can clearly be attributed to the intensity of human activity.

Eighteen resident species of seabirds, belonging to seven families, have been recorded from FFS. An additional four species known from the main islands do not nest in the Northwestern Hawaiian Islands. Several species of shorebirds and seabirds that nest elsewhere also visit FFS and other Northwestern Hawaiian Islands. Amerson (Ref. 7) has summarized the data on FFS birdlife up until 1969. Amerson's report illustrates the decrease and subsequent increase in breeding species of seabirds at Tern Island that followed the changing condition of vegetation when the island was reconstructed. That the process of recolonization is continuing is evidenced by the increasing populations and varieties of seabirds on Tern Island since Amerson's report was published.

The six seabird species for which breeding on Tern Island was confirmed by Amerson (Ref. 7) include Black-footed Albatross, Laysan Albatross, Bonin Petrel, Wedge-tailed Shearwater, Red-tailed Tropicbird and White Tern. Counts of Laysan Albatross and Red-tailed Tropicbirds since Amerson's report have remained reasonably constant. Estimates of Wedge-tailed Shearwater and Bonin Petrel numbers have varied radically, in large part because of the difficulty in counting nocturnal burrowing birds. Numbers of Black-footed Albatross and White Terns have increased appreciably in recent years. Other species recorded breeding since Amerson's report that were not breeding at the time of POBSP field work (1963-1969) include Christmas Shearwater, White-tailed Tropicbird, Blue-faced Booby, Red-footed Booby, Grey-backed Tern, Sooty Tern, Brown Noddy and Black Noddy. The increase in diversity of nesting species can be attributed in part to the continuing development of certain plant species (i.e. Casuarina for Black Noddies, Tournefortia for Red-footed Boobies).

One particular seabird species is worth special note. The Sooty Tern (Sterna fuscata) was recorded on Tern Island by the "tens of thousands" prior to reconstruction of the island in 1942. Amerson (Ref. 7) noted that the runway was used by Sooty Terns during the period between the island's abandonment in 1945 and its reoccupation by the Coast Guard in 1952, but none were recorded nesting subsequent to that date. Amerson attributes the immediate absence of the birds to overt control by the Coast Guard, but this in undocumented. The first nesting since 1953 on Tern Island was recorded in 1972. The breeding population exploded, so much so that a May, 1974 estimate of the breeding population reached 50,000 birds. As a result of bird strikes by Coast Guard aircraft, the FWS authorized a control program to discourage nesting of Sooty Terns by harassment of adults and destruction of eggs. In one two-week period in March 1976, the Coast Guard reported that 33,445 eggs were destroyed, but the program was unsuccessful in causing the birds to leave the island. As a result, flights of larger aircraft (C-130 and DC-3) were halted. What actually caused the sudden influx of birds to the island is not certain, although a simultaneous apparent decrease in the Sooty Tern population at East Island was noted by Sekora (Refuge file data).Balazs (pers. comm.) has also observed that the continued nesting activities of green turtles on East Island has inhibited Sooty Tern nesting in some areas, perhaps explaining, at least in part, the influx of birds to Tern Island.

Other terrestrial vertebrates of significance to plant and wildlife resources in the Northwestern Hawaiian Islands include a variety of small mammals that were inadvertently or intentionally introduced. The impact of introduced rabbits and guinea pigs on Laysan flora and fauna is well documented. Rats on Kure Atoll and Midway Islands have taken a major toll in ground-nesting birds, including a transplanted population of Laysan Rails introduced to Midway. Dogs have been associated with Tern Island personnel intermittently since the reconstruction of the island in 1942, and have been the subject of considerable controversy for their reported disturbance to seals and nesting seabirds. Amerson (Ref. 7) indicated that dogs have probably been a major factor in discouraging seals from pupping on Tern Island. Cats have also been recorded intermittently on Tern Island. Neither are now present.

ENVIRONMENTAL CONSEQUENCES

In view of the well-documented history of human impacts on the terrestrial ecology of Hawaiian atolls, it is not difficult to describe the types of adverse impacts that may occur as a result of various management options for Tern Island. However, accurately evaluating the magnitude and significance of those impacts is considerably more difficult. Indeed, the major focus of the FWS effort is the ongoing Tripartite Cooperative Agreement is an evaluation of the relationship of commercial fishing and seabird ecology. Shallenberger's (Ref. 154) research plan for this study provides an overview and detailed bibliography relevant to this assessment. No attempt will be made here to second guess the final results of this research effort, but rather to focus on the Tern Island management question and its relationship to the broader picture.

There appears to be little doubt that implementation of the abandonment alternative will reduce the ongoing adverse impact on the terrestrial ecology of Tern Island. However, without a determined effort to prepare the runway surface for encroachment of vegetation, it is anticipated that several years will elapse before vegetation successfully spreads over the surface on its own. In the meantime, the Sooty Tern colony is likely to continue spreading onto the runway from the edges, although the sparsely vegetated cobble along the runway frings will be the preferred habitat. It is unlikely that any other seabird species will colonize the open runway, at least in significant numbers, for several years after abandonment. Removal of the antennae with attached support wires is likely to reduce some mortality, although the significance of antennae at Tern Island is poorly documented. Although Tern Island already supports a greater diversity of nesting seabird species than other islands in the atoll, populations of several species (i.e. Wedge-tailed Shearwaters, Brown Noddies, Black-footed Albatross) are significantly greater on one or more other islands in the atoll. These species are likely to respond most favorably to the sudden lack of human disturbance. It is likely that the adverse impact of various exotic weeds on Tern Island will continue to be felt throughout FFS (and perhaps onto other Northwestern Hawaiian Islands) for years to come through the dispersal of seeds by birds, wind, water and even man through unauthorized visitation.

The outpost management option will also permit significant expansion of seabird colonies as a result of reduced disturbance, but this effect will be limited to the extent that remaining island caretakers enter the nesting areas. It is probably not feasible to totally restrict access to seabird colonies in view of the requirements to seek some form of recreation, to monitor and maintain the seawall and to limit encroachment of nesting birds onto the runway (to allow continued use by light twin engine aircraft.) Support of on-island seabird research by the outpost facility will result in continued, if not increased, intermittent disturbance to birds. Some of the effects of human disturbance in seabird colonies that have been documented include abandonment of eggs, exposure of chicks to extreme temperatures, crushing of nesting burrows, and disturbance of courtship rituals, and overall reduced reproductive success. The significance of these impacts varies widely with the timing and duration of disturbance, the sensitivity of the individual researcher to the behavioral responses of individual birds, the density of the colony, and the particular species involved. Experienced researchers can mitigate these adverse impacts significantly, but inexperienced intruders into a seabird colony may be totally insensitive to the type and magnitude of impact.

Presumably under the outpost station alternative, access to other islands in FFS would be limited to researchers conducting approved studies in the refuge. Although this activity would be limited in scope by comparison to larger scale research facilities, the adverse impacts on terrestrial ecology of relatively undisturbed islands can be of long term significance. The wide diversity of exotic weeds on Tern Island makes it a virtual certainty over time that visits by researchers to other islands will assist in the dispersal of some plant species. The presence of Cenchrus (burrgrass) on Laysan Island can very possibly be explained by the movements of researchers (Herbst, pers. comm.). Other examples of exotic weeds transported to remote Hawaiian atolls by military personnel have also been documented. It is very likely, however, that researchers conducting approved studies would be willing to take the necessary precautionary measures to minimize the risk of inadvertent dispersal or new introductions.

Either of the higher intensity research management options for Tern Island would likely accelerate the rate of dispersal of exotic weeds throughout FFS, although this would depend upon the types of research supported by the facility and the subsequent frequency of inter-island movement. Continued air traffic and shipment of supplies and equipment to the support station would probably not differ appreciably from the Coast Guard era. In fact, it is possible that frequency of aircraft landings would increase, as many researchers would not have the time nor the inclination to remain on the island for extended periods. Clearing of the runway to permit increasing frequency of flights would, in turn, retard the expansion of seabird colonies on the island. The impact of a greater number of researchers on the seabird colonies at Tern Island and elsewhere would depend upon the nature of the studies and the frequency of disturbance in the colonies. There is considerable concern among researchers with experience at FFS that more than 1-2 researchers on any one of the islands at a time would be excessive, in view of the documented disturbance of birds, seals and turtles. Again, it is possible to mitigate this impact through appropriate timing of research activities, avoidance of sensitive areas and other measures. Placement of permanent, but low profile, facilities on outer islands may be considered as a measure to reduce the frequency of inter-island trips and to allow nesting birds and other wildlife to accomodate to the presence of structures.

The various fishing station alternatives under consideration for Tern Island may impact seabird populations in several different ways, although there are reasonable measures that can be taken to mitigate at least some of these impacts. Fishing options that involve only movement to and from Tern Island (albacore, offshore trap, precious coral, ahi and bottomfish; and aku if no bait is taken in FFS), will probably result in minimal direct impact on seabirds nesting areas, except that which is likely to occur on the island itself as a result of human presence. None of these options require on-island living quarters, but it is reasonable to expect that fishermen would wish to spend time off their boats between fishing trips. If this occurs, disturbance to Tern Island wildlife may increase if fishermen are not occupied with other work while on the island. In addition, the requirement to maintain a clear runway to allow air shipment of fish by large aircraft, and the flight activity itself, will require overt control of the tern population and disturb other seabird populations as well. The additional threat of inadvertently introduced predators (i.e. rats) will be possible if fishing boats are allowed to dock at the island, to offload fish and take on ice, fuel and other supplies. Of course, the same risk applies if other boats (pleasure, research, etc.) dock at the facility, but the expected frequency of use would be very low by comparison to the fishing station options.

As the frequency that supplies are transferred at the island increases, the risk of inadvertent weed and pest insect introduction also increases. Dr. John Beardsley of the University of Hawai, in a September, 1977 letter to the FWS Refuge Manager, noted that a species of grasshopper (Schistocerca nitens nitens) discovered on Nihoa and Necker Islands belonged to a genus of grasshopper known to be a serious pest species, that could conceivably seriously disrupt the simple ecosystems of these islands. The surprisingly large diversity of exotic insect species found on Tern Island by this investigator attests to the effect of intensive human use (Ref. 25). It should be noted and reemphasized that the threat of pest insect and exotic weed introduction to Tern Island extends far beyond the limits of the island itself. The ecology of this island is already highly disturbed, yet its role as a reservoir for dispersal to other islands at FFS and elsewhere in the archipelago is inevitably a more serious threat to the refuge. POBSP banding records of seabirds clearly document frequent movement of birds between FFS and other islands of the archipelago (including the main islands) and less movement even to more distant locations such as Alaska,Johnston Island, Wake, and Palmyra. Seeds of many weed species attach readily to the feathers of birds, float on the ocean or blow in the wind. Also, this problem is not confined to those plant species that establish inadvertently, as several ornamental plants purposely brought to Tern Island remain a threat to the natural ecology of other islets as well.

Dependency of fishing boats (or research vessels) upon Tern Island for fuel supplies will inevitably result in a greater frequency of diesel fuel pollution of refuge waters. Also, in the absence of adequate enforcement capability, it is anticipated that wasting of bilge oil and untreated sewage will continue with considerably greater frequency. The threat of a major fuel or oil spill event should not be discounted, as the frequency of shipwrecks within FFS attests to the navigation problem. Frequent transfer of fuel by barge carries with it significant risks. Major oil pollution in refuge waters would have direct adverse impacts on both aquatic and terrestrial species (see Sections 7e and 7h). Frequent oil spills at other locations in recent years have documented the fact that seabirds are hardest hit in the vicinity of large nesting colonies. Oil contamination takes its toll directly through toxic effects and through debilitation from exposure after oil-soaked plumage loses its insulating qualities (Ref. 5). Even sub-lethal amounts of oil on an adult bird have been shown to lower hatching success when transferred to their eggs. There are significant differences between the effects of crude oil and various refined fractions. Even diesel oil has been shown to have major adverse effects, including extensive liver damage in test birds (Ref. 4). Perhaps the most serious aspect of a major oil spill at FFS would be the lack of opportunity to respond quickly enough, with enough men and equipment, to contain the spill and to disperse and/ or rehabilitate wildlife. It should be noted that the adverse impacts of a major oil spill on seabird populations can not be measured simply in terms of the numbers of birds directly affected. Very low annual reproductive potential of most marine bird species will mean that recovery from a disastrous season will be very slow. If the event occurs during a natural low population period (i.e. during a shortage of food supply), the long term effects can be very significant.

Other anticipated causes of seabird mortality that may result from a significant increase in fishing activities at FFS include the subtle effects of depleted food supply, disturbance of feeding behavior and the more obvious and direct loss of birds directly to fishing techniques. It is unlikely that efforts to obtain baitfish within refuge waters will result in significant direct mortality of seabirds, except incidental losses in seine nets or effects of disturbance near nesting colonies. However, indirect impacts through depletion of seabird food resources could be important. Ongoing Tripartite studies of seabird feeding habits are focusing on this particular question and are expected to yield at least some of the data necessary to establish whether or not this relationship is significant. It is anticipated that inshore feeding terns will be most directly affected.

Primary offshore food resources of seabirds are directly related to tuna schools that are presently harvested primarily by Japanese fishermen, and will inevitably become a major target of Hawaii-based fishermen if support facilities are available. To this extent, the indirect impact of a management decision for Tern Island on seabird populations of the refuge is very real. The dramatic effects of over-exploited fish resources on seabird populations elsewhere in the world has been well documented. (Refs. 52, 101). However, in the most dramatic instances, direct competition between seabirds and fishermen for the same prey has been involved. In the Hawaiian situation, available data suggest that offshore feeding seabirds and pelagic fishes (i.e. aku, ahi) share, rather than compete for, the same or similar prey resources. To this extent, it has been argued that some depletion of tuna stocks would "leave more for the birds." However, the intimate dependency of many seabirds on the prey fish chased to the surface by tuna schools makes it very likely, but undocumented, that depleted tuna stocks would make prey less available to the seabirds.

Finally, it should be noted that significant seabird mortality has been attributed to net and longline fishing in other areas of the world. (Ref. 162) Of particular relevance to the Hawaiian situation is the distressingly large number of banded Hawaiian seabirds, particularly albatross, that are recovered as mortalities from Japanese longline tuna fishing operations (Ref.144).

Any other management option that involved intensive human use of Tern Island, similar to that which is now occuring, is expected to have similar impact on the terrestrial biota. Non-consumptive recreation and education could be accomodated on the island, but the requirement for frequent flights between Honolulu and FFS would create greater disturbance to nesting seabirds than is now the case. Movement of curious "naturalists" and other visitors would have to be rigorously controlled if the integrity of the resident seabird colonies was to be preserved. There appeared to be almost universal agreement in the interview process that intensified recreational or educational use of the lagoon and other FFS islets should not be accomodated because of the anticipated disturbance of wildlife.

Sport fishing and aquarium fishing options are not expected to have significant adverse impacts on non-endangered terrestrial biota, except to the extent that unauthorized landings on other FFS islands would likely occur, and disturbance to seabird colonies would result.
Potentially adverse impacts could only be mitigated with strict enforcement

of regulations to limit these activities to designated areas, away from nesting islands. Such restrictions would be most acceptable to the sport fishing enthusiasts who would probably be more interested in larger offshore fishes anyway.