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ENVIRONMENTAL ASSESSMENT FOR PLANNED CHEMICAL FISH COLLECTIONS IN THE VICINITY OF KANEOHE BAY, OAHU, HAWAII

PROPOSED PROJECT

The purpose of this project is to investigate the community structure of smaller, more sedentary, cryptic species such as the gobies and blennies that can not be censused using visual techniques. The high species diversity in coral-reef fish communities often is due to these small, cryptic species and thus it is important to understand these smaller fishes that may serve as food for many of the larger species. Although visual censusing has been used to provide baseline data on the larger fishes present in and around Kaneohe Bay, comparable data for the smaller species are not available. This proposed study would complement the studies of others on community structure, and provide information of fish assemblages and their association with specific habitats.

There has been much confusion in the literature concerning the mechanisms that control coral-reef fish communities, and whether predictable assemblages occur. Generally, for those using visual techniques and larger species, workers in the Pacific (mainly Australia) and the tropical Western Atlantic have obtained conflicting results. Whether the mechanisms controlling community structure differ between these two oceans or whether the differences relate to the techniques used by these workers is not known. By repeating the identical methods I have used in the Atlantic here in Hawaii to study small, cryptic species, I should be able to determine if real differences exist. It is important to understand if basic differences do exist because if they do then the many studies done in the Atlantic should not be applied to Hawaii when trying to understand community structure and recruitment in relation to managing these resources.

Because these smaller, more sedentary, cryptic species can not be censused using visual techniques, it is necessary to use the technique of small rotenone collections within specific habitats. It is proposed that a transect be run through Kaneohe Bay and outside to a depth of around 30 meters, and that small rotenone collections be made in the different habitats that occur across this depth range. Based on my work in the Western Atlantic, it is anticipated that around twelve specific habitats will be identified. In order to recognize species assemblages at these sites using detrended correspondence analysis, it is necessary to make four collections from each specific habitat. The DCA analysis then will cluster collecting sites based on the number of species and individuals taken at those sites. It is estimated that a total of 48 separate collections will need to be made.

One liter of liquid rotenone will be used at each collection site. This is enough to cover an area of approximately 25 square meters (5m x 5m). No collections will be repeated at the same site and the collecting effort will be spread over the period of a year. In addition, sampling will be scheduled so that collections will not be concentrated in a particular area within a given time period. For example, if a collection is made at a patch reef in Kaneohe Bay one week, the next week the collection would be made at a depth of 20 meters outside of the Bay. Times and places will be chosen with great sensitivity to possible observation of the collecting by Hawaii residents, and every effort will be made to make collections at times and places where I would be most likely to encounter few people. Collecting sites also will be cleared with the Hawaii Institute of Marine Biology.

JUSTIFICATION OF PROPOSED ACTION

The use of chemical collections is justified because there is no other method that can be used to obtain data on the small, cryptic fish species that are present in and around Kaneohe Bay. Information on the species present, their relative abundances, and their association with specific habitats is necessary if one is to understand the community structure of the fishes in Kaneohe Bay. A management plan for the natural resources of Kaneohe Bay can not be complete without this important information. This study will be coordinated closely with the Hawaii Institute of Marine Biology as a part of the Main Hawaiian Islands Marine Resources Investigation Kaneohe Bay Project.

DESCRIPTION OF AFFECTED ENVIRONMENT

I plan to make four collections each at a maximum of 12 different habitats that will correspond with similar habitats in the Western Atlantic. Some of these specific habitats may not be present in Kaneohe Bay, and thus would be excluded. The habitats as previously defined for the Western Atlantic are: patch reef, spur and groove, shallow forereef, dropoff, coral rubble, deep seagrass, shallow seagrass, sand, offshore rock, mainland rock, mangrove, tidepool-strand.

TECHNICAL, ECONOMIC, SOCIAL AND ENVIRONMENTAL CHARACTERISTICS OF THE PROPOSED ACTION

Technical Characteristics

The active chemical ingredient in the ichthyocide to be used is rotenone ($C_{23}H_{22}O_6$), an extract of the roots of plants of the Leguminosae, that has been used for collecting fishes by the scientific community for over 40 years. Rotenone interferes with the respiratory process in fishes, resulting in suffocation and death. Most invertebrates are much less sensitive and negative effects on corals and other important habitat species are not expected. Parrish (1983) has summarized the potential effect of rotenone on birds, turtles, mammals or humans as follows "No harmful effects have been shown to birds, turtles, mammals or man as a result of repeated contacts with water in which rotenone was used (USDI 1949). Many fishery workers have swum repeatedly through thick clouds of rotenone in water. Prevost (1960) has pointed out that 'drinking the water...though it is toxic to fish, is not harmful to mammals or humans with the concentrations used,' and that 'there is no danger in eating fish killed by rotenone.'" Parrish (1983) also points out that only very low concentrations (around 1 ppm) are needed to kill fishes and that rotenone is not very stable when exposed to warm temperatures and sunlight. Because of the rapid dilution of these low concentrations in the open waters, and its instability, toxic concentrations only would be present in relatively small areas for a few minutes. These properties make rotenone a routine tool in fishery research and management.

Economic Characteristics

The majority of fishes that will be taken using this technique will be small, such as blennies and gobies, that do not have any direct market value. These fishes could serve as food for fishes that are fished for sport or commercially, but the small numbers that will be taken should not have an impact on the feeding of these larger species. A few incidental species that hide in holes during the day might be taken, but these numbers would be low. The 'U'u or menpachi (*Myripristis*) would be an example of such incidental species.

Social Characteristics

Because of irresponsible use of chemicals in the past for taking of fishes for food, aquarium specimens and other purposes, there is concern that Hawaii residents not be led to believe that the use of such chemicals is condoned for use by the general public. Because of this it is prudent to keep a very low profile when making scientific collections using an ichthyocide. I have had over 20 years of experience making fish collections using rotenone throughout Mexico, Central and South America and never have encountered any problems. I use very small quantities of ichthyocide and am very aware of problems relating to the concerns of people in the area. I always make an effort to make collections at times and places where I am likely to encounter no or few people.

In deeper water where SCUBA is used, it is very unlikely that anyone would be aware that a collection had been made because we scare away larger species before collecting and only take small species, thus larger individuals floating to the surface are unlikely. In addition, at the beginning of a station the divers stay above the small rotenone cloud and catch any specimens that might drift up towards the surface, and then go to the bottom to pick up the small species.

The few collections that will be made in shallower areas near shore will be made with great caution and every attempt will be made to avoid areas where there are people. We also will be careful not to make a collection if there are schools of fishes such as herring, anchovies or silversides in the area that might be killed and would be obvious.

Environmental Characteristics

The impact of the small rotenone collections will be the removal of most of the small, cryptic fishes from the 5m x 5m area being sampled. Information on previous sampling with rotenone in Hawaiian waters indicates that recolonization of the fish communities to a similar composition on a patch reef in Kaneohe Bay took one to two years (Brock et al. 1979, Wass 1967). Shaklee (1979) reported on a series of three collections with rotenone in three successive years at the same site on the Waianae coast. He found that there was no consistent trend in the total number of fishes, total biomass or number of species at the site, and there was no measurable impact a year after a collection was made. The above studies were efforts to completely remove all fishes from the sampling area. Thus, the impact of these studies should be considerably greater than the potential impact of the small collections we propose to make because we will make an effort to chase larger species away from the area before samples are taken.

Based on my many years of experience in making collections in the tropical Western Atlantic, when one observes a small area that was collected the day before, it is not possible to tell that a collection was made because only the small, cryptic species are missing and the larger fish species are present at the site.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. Chemical collections will result in the removal of small, cryptic fishes from 48 5m x 5m sites distributed over 12 different habitats in the vicinity of Kaneohe Bay, Oahu, Hawaii over as one year time period.

2. The natural communities at these sites should renew themselves in less than one year and should be similar to their original condition.

3. Water quality will be impaired for a half hour at the most and will be very localized (5m x 5m) and at no time will there be a condition that is deleterious to the health of humans, seabirds, turtles or seals.

4. Through judicious selection of sites and collection times, the public should not be affected.

5. There is no substantial degradation of environmental quality nor any long-term effects.

6. No rare, threatened or endangered species of animals or plants will be substantially affected.

7. There is no conflict between the proposed action and the State's long-term environmental policies or goals. This action should contribute to assessment of the marine resources of the state and aid in informed resource planning and management.

8. The action has no direct substantial effect on the economic or social welfare of the community or State. Negative effects are negligible due to the small quantity and kinds of fishes taken, and the highly localized area.

9. There appear to be no measurable environmental effects.

Because of the apparent lack of any significant persisting environmental impacts of this type of action in the past, because the similarity of the present action to past actions of this type permits a confident prediction of no significant persisting environmental impacts, and because of the clear, positive value of this research in terms of resource management, scientific knowledge and education, this proposed action warrants a NEGATIVE DECLARATION. This is in accordance with the Hawaii Revised Statutes Chapter 343, which recommend the identification of classes of actions that probably will have minimal or no significant effect on the environment.

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1990-92 MHI-MRI PROJECT PLAN

PART I: BACKGROUND INFORMATION

In 1987 an initiative began to develop a project that would evaluate factors affecting the abundance of Hawaii's coastal marine resources and provide information necessary for the design of appropriate management policies to resolve fisheries and environmental issues. The question was raised by Shomura (1987) in a general summary of published data from the State's commercial fisheries, documenting an apparent decline in the nearshore and neritic-pelagic catch. He pointed out the need for a more detailed evaluation of whether these trends resulted from changes in market preferences and target species of the commercial fishing fleet or from biological and environmental causes, including overfishing.

A workshop of oceanographers and fisheries scientists was held during December of 1987, at the request of the Chairman of the Board of Land and Natural Resources, resulting in a document summarizing the necessary components and priorities of a longterm study to fill in the gaps in our understanding of factors impacting coastal ecosystems (Pooley et al., 1987). The urgent need to examine the current status of marine fishery resources in the Main Hawaiian Islands was raised repeatedly throughout the workshop. Fishing pressure, pollution, ecosystem changes, habitat alteration, natural fluctuations and competing uses were perceived as potential reasons for the observed depletion of Hawaii's nearshore marine resources. Overfishing and human-induced environmental changes were cited as the probable primary causes. The workshop identified three general goals that need be met in order to accomplish the necessary assessment, monitoring, and enhancement or maintenance of resource quality and abundance. These were: 1) to understand the biology and productivity of important living marine resources, particularly fishery resources, 2) to determine the impact of human activity and natural change on the marine environment and its living resources, and 3) to develop management strategies for conserving and enhancing these resources.

Researchers from various State, Federal and private institutions involved in this preliminary planning agreed that although it was premature to map out the precise nature of the research plan, it would be important to identify the key problems which would motivate and constrain the project early in the research process. They felt that the development of basic data sources constituted an important contribution to the research initiative. An emphasis was placed on issue-oriented studies which would provide management recommendations, establishment of an ongoing process of resource monitoring and public education, and identification of important fisheries issues.

During 1987 and 1988, the State's Division of Aquatic Resources (DAR) accomplished two surveys of a wide segment of Hawaii's fishing, research, conservation and management communities (Harman and Katekaru, 1988; DAR, 1988). These studies established the existence of a number of specific concerns regarding the use and protection of Hawaii's fisheries resources. The problems identified included: unrestricted use of nets and other nonselective gear; overfishing; the lack of licensing, recording and regulation of recreational catch; the lack of minimum size limits for many species; inadequate or nonexistent regional and seasonal closures protecting juvenile and reproductive organisms; conflicts of interest between fisheries and recreational activities; the need for additional quotas and bag limits; lack of communication between management, researchers and resource users; and inadequate enforcement. Edible seaweeds, reef fishes, lobsters, crabs, opihi, octopuses and carangids (ulua) were among the groups most frequently listed as being significantly depleted. Fishermen made similar observations to those raised by researchers and administrators. The most frequently mentioned concerns for Hawaii's coastal resources were with reference to overfishing, the lack of adequate fisheries management policies and the need for more information regarding the biological and ecological interactions occurring in coastal ecosystems.

Following this period of general discussion and planning, the idea for the MHI-MRI Project was approved by the Legislature and funds were appropriated to the State of Hawaii's Department of Land and Natural Resources. A MHI-MRI Council was formed with representatives from DAR, the National Marine Fisheries Service's Southwest Fisheries Center Honolulu Laboratory (NMFS), the University of Hawaii's Sea Grant Program (UHSG) and Hawaii Institute of Marine Biology (HIMB), the U.S. Fish and Wildlife Service (USFWS), and the Western Pacific Regional Fishery Management Council (WPRFMC). While all these entities were represented on the MHI-MRI Council, the degree to which there would be active participation varied between organizations. This was due in part to differences in the regional jurisdiction of these institutions. While all of the State and Federal entities represented on the MHI-MRI Council were equally interested in the development of the project, NMFS, USFWS and WPRFMC already had significant responsibilities farther offshore. Thus, although the project would have the full cooperation, and technical and logistic support of these institutions, the bulk of the research would be covered by DAR, UHSG and HIMB. This was in contrast to the foregoing interagency project conducted from 1975 through 1982 in the Northwestern Hawaiian Islands (Grigg and Pfund, 1980; Grigg and Tanoue, 1983), where the bulk of the responsibility for research pertained to Federal agencies.

A series of research proposals were funded under MHI-MRI during fiscal year 1989-90, with agreement for extensions during 1990-91. These included several studies proposed by investigators from UHSG quantifying: the amounts and trophic dynamics of landbased nutrient subsidies (both natural and human-induced); the extent and impacts of siltation due to industrial and agricultural activity; distribution, abundance, reproduction and mortality of selected pelagic species; and the impact of recreational fishing on reef fish abundance and community structure. A collaborative study designed by HIMB was also funded to evaluate general ecology (habitat, community structure, distribution and abundance) of exploited species and rates of removal by recreational and commercial fisheries in Kaneohe Bay. In addition, a study by the Oceanic Institute was funded to examine resource use in Hilo Bay and the feasibility of stock enhancement through release of artificially reared mullet and moi. These pilot studies were funded before the planning process had been fully completed as a means of obtaining some immediate results and testing the methodology of monitoring and assessment on a small scale before extending activities to a broader area of the Main Hawaiian Islands.

However, many of the important issues recognized and targeted at the conception of the Project have not been addressed by proposed research. In order to keep sight of these goals, it is important to carefully think through the various components of the Project and the best way to meet the general and specific goals as quickly as possible with the financial and human resources available. The limitations of time, funding and personnel dictate the importance of the selection and prioritization of research to be undertaken. The next phase in the development of the Project should include a systematic review of priorities, coverage and gaps in the information being collected, as well as a methodical consideration of existing biological, fisheries and environmental data, in order to identify the resources and habitats to be the primary focus of research. At the same time, an examination of methods of monitoring stock abundance, levels of fishery exploitation and environmental quality would be useful. The following is an attempt to guide the planning effort in a direction that will lead to a rapid identification of research priorities, the development of a consensus concerning the most efficient means of obtaining the needed information, and the initiation of a series of activities that will meet the expectations and needs of the MHI-MRI Project to provide a basis for rational management of the marine resources of the Main Hawaiian Islands.

PART II: GUIDELINES FOR MHI-MRI DURING 1990-92

I. Definition of terms - To avoid confusion it is important to standardize the terminology used in this project, with regard to the scope of the research and boundaries of the resources being studied.

A. It is useful to delineate the hierarchical position of the MHI-MRI Project within the Department of Land and Natural Resources. In this context, words such as program, project, and study have specific meanings. MHI-MRI is a project, with the bulk of funding provided through the LNR Aquatic Resources and Environmental Protection Program (LNR 401). The various subprojects can be referred to as studies or jobs. This terminology will be used throughout this document.

B. Coastal or nearshore - The area of concern for research should be defined on the basis of depth, distance from the coast or range of target species. Some plausible suggestions are:

1. Coastal zone out to 2, 3, 12 or 200 miles.
2. Shoreline and island shelf (or slope) to 100 fathoms.
3. Population boundaries of nearshore species (which must then be defined through research).

C. Resources - A limited number of the principal fisheries resources should be targeted for the early stages of the project, with the purpose of developing a general understanding of levels of abundance, exploitation and depletion.

1. For example, fisheries or groups of exploited species could be selected for study on the basis of:

a. Most economically important (having the highest per-unit price, volume of landings, or consumer preference; producing the most commercial and/or recreational revenues; or some combination of these)

b. Showing the highest level of exploitation (estimated from the sum and ratio of fishing and natural mortalities) and/or the most marked decline in abundance (estimated from field census data or trends in CPUE).

2. The selection of indicator species for ecological impact studies is also recommended.

a. If we could develop an understanding of environmental, biological and ecological factors affecting the abundance of a few representative species or groups, we could establish a practical basis for monitoring and management of our coastal resources.

b. If we do not limit the scope of our efforts to establish the impact of fisheries and environmental change on community structure, we risk the pitfalls of trying to evaluate a system that is multiply complex and variable with limited time and personnel.

3. The important resources belong to five principal categories, two of which are essential trophic elements as well as components of the substrate, microhabitat, flora and fauna of coastal ecosystems.

   a. Fishes (several subgroupings can be suggested; see III)
   b. Crustaceans
   c. Mollusks
   d. Corals
   e. Algae

II. Mapping of Resources and Habitats. A graphic summary of baseline information would be useful to define resource utilization, demographic aspects and physical factors affecting the regions under consideration. One method would be to develop a coastal map which would show the study areas, boundaries and overlap of various fisheries and fisheries habitats, areas of urban and industrial development, recreational zones, and locations for which information is needed. Early in the development of MHI-MRI it was recommended that such work be undertaken, with individual maps or groups of overlays of biological and environmental data representing component studies of the overall Project. Such a document would be useful in itself and should include:

A. Main Hawaiian Islands (Oahu, Hawaii, Maui, Kauai, Lanai, Molokai, Niihau, Kahoolawe)

B. Depth contours (possible sources: Army Corps, NOAA, USGS)

C. Substrates (coral,boulder,sand,mud,etc.; sources as in IIB)

D. Major rivers (DLNR/CPSU Hawaii Stream Assessment maps)

E. General salinity contours (sources as in IIB)

F. Areas and types of coastal development

G. Geographic distributions of species and areas with characteristic community structure

H. This information can be consolidated, displayed, published and made available to a variety of administrative and legislative users through the State of Hawaii Ocean and Coastal Information Management System (GIS, Geographic Information

System), putting this system to the use for which it was designed and implemented.

III. Identification of fisheries. Fisheries should be subdivided for research into categories which are meaningful for management purposes. Various schemes have been proposed:

A. Shomura (1987) proposed a general classification of fisheries resources and identified apparent trends in each category, corresponding to possible lines of research. MHI-MRI studies should concentrate on the first two categories which are the most understudied, show the greatest evidence of depletion and are within the usual range of State fisheries jurisdiction and research:

1. Nearshore (coastal)
2. Neritic-pelagic
3. Slope & seamount
4. Pelagic

B. Parallel in many ways to the above classification is a system recently proposed by DAR's statistical unit. Appendix 1 shows a typical summary. It can be seen that some categories are quite specific, whereas others contain unrelated species. The structure of the database is such that alternative categories could be selected and the corresponding summaries generated relatively easily. The best method of summarizing this information is still under consideration. The MHI-MRI Project could contribute to this effort by helping to establish a consensus on the most useful classification.

C. Another method would be to classify species complexes by geartypes. A list of geartypes and species guilds is given in Appendix 2, which also uses the categories recorded in the DAR database.

1. The list shows that some species are caught by several types of gear and most geartypes catch various unrelated species, which are important considerations when evaluating the impacts of fishing on the abundance of any one species.

2. This classification has the advantage that management recommendations could be implemented through gear restrictions, and compliance monitored from shore, an important consideration given the limited enforcement personnel.

3. Although individual and population growth and mortality occur at the species level, both economic rent and fishing effort are more related to geartypes than to species for most fisheries.

IV. Review of fisheries statistics

A. Existing data on catch and effort must be carefully reviewed and summarized for several reasons.

1. To evaluate trends in reported landings and identify species/fisheries of high priority for research. Previous documents have pointed out the need for a clear understanding of the historical database, which is bound to be imperfect but will provide a basis on which to determine what trends are apparent and where further research is necessary. Some annual and monthly summaries are already available, but a methodical review of the data is needed.

2. To evaluate the scope, adequacy, discontinuities in the data, etc.

B. Available information is of four principal types:

1. Total volume and commercial value of landings by species or groups of species. If steps III and IV are carefully thought out, the catch of species which are exploited together or occur in similar habitat can be summed and trends in landings evaluated.

2. Catch and effort data by grid areas and species groups throughout the Hawaiian Islands. A summary of this information showing geographic trends in landings, species composition and CPUE by ten year periods, from 1950 to the present, could be included as several overlays to the habitat map described in II.

3. Field survey data (fish density and species composition).

4. Fishing activity surveys (creel censuses).

C. On a historical basis, data are available primarily for commercial landings, but few recreational fishing methods are not represented commercially as well. The first step should be a careful evaluation of the present working definition of commercial fishing, with the intention of estimating the portion of catch and effort being reported.

1. Many licensed commercial fishers are actually recreational or subsistence fishers who sell part of their catch.

2. Some preliminary surveys of recreational fishers have already begun (HDAR-NMFS-OMNITRACK) and others are planned for the near future (HIMB-Kaneohe Bay, OI-Hilo Bay). It is important that good communication be maintained between these studies so as to avoid repetitive surveying and encourage the development of a more complete database through complimentary data collection.

3. More information will become available concerning the preferences, catch and CPUE of recreational fisheries. Eventually a recreational license will be established, with associated authority to collect more complete catch and effort information.

4. In the meantime, an effort should be made to estimate the volume and species composition of unreported recreational catch, both presently and historically (see V).

   a. There is an indication that recreational fishing may represent 40-60% of the volume of commercial landings, although the actual percentage depends on the definition of recreational fishing. If this is the case, these fisheries merit a data collection effort equivalent to that expended on commercial catch data in order to develop more accurate estimates of total catch, CPUE and temporal patterns.

   b. The inclusion of recreational fisheries will mean an increase in estimated landings by inshore handline, light tackle, trolling, diving, wading, trap and net fisheries. Creel censuses will attempt to estimate which fisheries and by what proportion reported landings must be increased.

5. The historical database could be developed through a socio-economic study, summarizing census and market data, as well as information obtained by interviews (see Leriche, 1982). First order information on volume of landings could be obtained from a survey of reports produced routinely by dealers, buyers and shippers.

D. It is important to look at trends in fishing effort as well as total catch. Information on volume alone is of limited value. As pointed out by previous publications and discussions, shifting trends in fishing effort and market preferences must be identified in order to interpret trends in total catch. Some of this information is already in the DAR database on a per-landing basis. However, even landings as a unit of fishing effort will need to be standardized in some way:

1. The fishing effort expended to produce each landing unit (number of days/fishermen/boat-hours etc.) is varied.

2. Fishing power per day of effort has increased with the use of more powerful engines, hydraulic gurdies, and more advanced methods of fishing and locating fish.

3. Quantifying the changes in fishing power and effort by the various fleets over the years in itself represents a series of complex studies.

E. Putting existing catch and effort data in context, along with the information obtained from creel surveys of recreational and commercial fishers, it will be possible to identify trends in overall volume of landings and CPUE, recognize gaps and representativity of these data indicating areas where further study is needed, and prioritize species groups or fisheries for study.

1. The flow chart in Figure 1 outlines a stepwise method which would bring the MHI-MRI Project through this initial evaluation phase. The time frame for this work would be approximately 2 years, after which there would be a clear indication of the necessary direction of further research.

2. In the meantime, an effort can be made to determine the criteria to be used in the selection of fisheries/species groups for study.

a. Selection criteria could be determined by popular referendum, involving the participation of fishers, administrators, researchers and the public (see example Oceanic Institute).

1. By this method, all concerned would confer on selection criteria and the relative importance (weighting) of each.

2. These criteria would then be quantitatively applied to a list of commercial species (with corresponding catch and effort data) to come up with a prioritized list of fisheries to be examined.

b. Alternatively, species/fisheries could be selected by anonymous voting, either in response to a mailed ballot or at a meeting of the public with fisheries and marine biologists.

c. Indicator species for the evaluation and monitoring of the impact of fisheries and coastal development, pollution, etc. on nearshore resources should be identified through studies of community and population responses to removal by fishing, increased mortality, and decreased growth and reproduction due to environmental change, habitat alteration, etc.

V. Definition of fishing fleets and fishermen. In the same way that fisheries resources are mapped, the major fishing fleets and their zones of operation should be located with respect to the Main Hawaiian Islands. Much information is already available, but will need to be summarized. Gaps in existing information can then be identified and steps taken to obtain this information. The general goal should be to define the numbers of boats, fishermen and gears operating in the coastal zone of the Main Hawaiian Islands, and their respective areas of operation. Some notes on commercial & recreational fisheries have been made in part IV-C of this plan. Sources of baseline data include:

A. DAR catch reports by grid areas.

B. Commercial & recreational boat listings (DOT/Harbors Division and US Coastguard) could be used to develop a vessel inventory, to include information on the type(s) and area(s) of fulltime or parttime fishing activity.

C. Gear types, gear abundance and areas where use is permitted (DOCARE/DAR).

1. Mapping of prohibited areas & MLCD's (DAR).

2. Basic information on the amount and types of gear sold could probably be obtained from a survey of marine supply dealers.

D. Dockside surveys (creel censuses) can get at these and other questions, including catch and effort data by geartypes and species. Survey questions should include most of the following, although not all information will be available from every person interviewed:

1. Effort (mostly for current trip only)
   a. geartype or fishing method
   b. numbers of days/months, trips and hours fishing (ask for the first three items for the year as well as for the current trip)
   c. numbers of lines, hooks, nets, etc.
   d. length, meshsize etc. for 1c.

2. Catch
   a. species and relative abundance (rough percentage is more useful than rank abundance e.g. 1-10)
   b. size (dockside sampling methods can be developed)
   c. numbers of fish, kg/lbs per day, week or month (be flexible, but specify)

3. Several historical surveys have been made of recreational fishermen (Hoffman and Yamauchi, 1972,1973; SMS Research, 1983; Omnitrack, 1988; USFWS, 1989). Although these could be improved upon they should be included in the database.

E. Information on Hawaii's human population can be obtained from standard population censusing done every 10 years by the Federal Government. A census will be made during 1990. Data obtained from the census include:

1. Size, ethnic composition, and principal source of income of the resident population (income subsample only).

2. Size of tourist population.

3. The most useful statistics for the purpose of determining the impact of human activity on coastal fisheries are:

   a. The ratio of #tourist/#residents per day (as opposed to the usual 6:1 ratio reported on an annual basis).

   b. The total number of these tourists and residents involved in fishing activities on a daily basis.

4. Some useful information may be obtained from DBED.

VI. Review of fisheries regulations. Summarize information on existing regulations: species, size limits, quotas and seasonal closures. This information could be summarized in 3-4 seasonal map overlays.

VII. Evaluation of past and present quality of Hawaii's coastal environment, with an emphasis on environmental parameters affecting growth, reproduction and survival of coastal species.

1. Freshwater runoff, coastal salinity and estuarine zonation.
2. Toxic effluents, sewage and industrial waste.

VIII. Literature search. Much information is available for the principal species, both in Hawaii and in other areas. A summary of pertinent information would be useful to all concerned and would ensure that valuable time not be wasted where data exist concerning:

A. Life history & reproductive biology.

B. Growth and mortality.

C. Estimates of biomass, fisheries potential, and methods used to obtain these in Hawaii and other regions.

D. Successful and potential management and monitoring strategies for tropical species.

E. Standards of water and habitat quality in coastal ecosystems, data available for the Main Hawaiian Islands, and effective methods of monitoring.

IX. The above outline describes a means by which, MHI-MRI's focus can be clearly identified and priorities defined so as to set appropriate goals for the future.

A. A summary of the recommended proximate goals, objectives and activities is given in Figure 1. A succinct assessment of priorities should be the number one item on the agenda at present.

B. Later we can begin to isolate the various components of impact with regard to fisheries, habitat and environmental variables.

C. Much of the data described has already been collected or is generated by existing projects, but MHI-MRI can be instrumental in providing expertise and personnel to accomplish the synthesis and analysis that is needed.

D. A possible outcome of this evaluation phase could be a report which would summarize coastal habitats and fisheries, trends in catch and CPUE, point out problem fisheries and make specific recommendations for further study. The summary of fisheries and habitats would take about two years to complete, but the question of general planning should be resolved as soon as possible.

1. This need not interrupt work already in progress

2. It will contribute to the definition of fisheries problems and key areas that are lacking development.

3. An immediate project should be the development of guidelines for future proposals. A simple document could be produced and circulated as a means of generating interest that would set forth areas of research, recommended proposal structure and annual deadlines for approval. Such a leaflet could follow the consensus regarding this general outline.

PART III: GENERAL RECOMMENDATIONS FOR PILOT STUDIES, THE INTERACTION BETWEEN MHI-MRI AND THE PUBLIC, AND THE DEVELOPMENT OF COLLABORATIVE RESEARCH

It is important to complete basic planning and organization, and determine how the MHI-MRI Project will generate a source of information that will be helpful for decision making and longterm management of Hawaii's coastal resources. The immediate emphasis should be on an identification and prioritization of research goals. The beginnings of this project were characterized by the careful consideration of goals and priorities. The concern for the development of an understanding of the reasons for the decline in abundance of our coastal resources was clear, as it was clear that fishing was considered to be the primary cause of this decline. MHI-MRI was funded with the objective of developing a database that would allow rational management decisions to be made. Inadequate fisheries management policies and enforcement were also mentioned, but these are issues which must first be resolved from the standpoint of research through adequate definition of what regulations need to be.

In order to do this, researchers must provide a clear definition of the amount of these resources that can be removed or negatively impacted by a combination of factors. A project with the primary goal of providing the guidelines for resource management must first seek to understand the extent of the resources. Adequate management depends on an assessment of the biomass and/or numbers of individuals comprising coastal populations and communities and what fraction of these can be removed without unduly impairing the productivity and viability of these ecosystems. Moreover, an evaluation of the minimum requirements of community size and diversity to ensure that these ecosystems can be maintained for future generations is needed. Factors impacting on coastal resources, whether through recreational or commercial fishing, habitat loss, pollution, or any given cause will tend to push resources towards these limits. Before we can determine the limitations on reduction of diversity and abundance, we need to know what resources we still have and where.

Drawing on the experience from the previous study of the Northwest Hawaiian Islands, it is clear that researchers have a widely varied range of interests and expertise. These different perspectives and approaches to problem solving can benefit the MHI-MRI Project, but it is essential that we agree upon both a general direction and the path we should take to get there. It is easy to become sidetracked into studies that may produce interesting and significant results, but will not provide the information needed to manage our coastal resources. The challenge is to approach the problem rationally, discern its basic components and systematically set about obtaining the information that is needed. As John Craven stated in his concluding remarks for the first Northwest Hawaiian Islands Research Symposium, "...though we may approach science with different missions in mind... gather your data so that it can be used to assess the significance of possible impacts".

Fisheries research is the most critical immediate priority of the MHI-MRI Project and an emphasis must be placed on the development and coordination of biological research with methods of monitoring physical parameters and other baseline information. In light of the amount of information to be synthesized concerning the extent of coastal resources in the Main Hawaiian Islands and the rates at which these resources are being removed by fishing, these issues must be given priority over other equally interesting but less pressing research questions. Time and again it has been shown that fishing mortality can be the major determinant of resource abundance. This doesn't mean that studies of alteration of coastal habitat, pollution and other types of environmental change cannot and should not be undertaken, merely that these studies should be coordinated with a the development of a more general understanding of resource abundance, growth, productivity and fishing mortality. To date no single study has been designed to make both environmental and ecological assessments.

It is suggested that initial research efforts be concentrated when possible into a few geographic locations where the combined studies will be able to cover the major components of the overall ecological puzzle. An effort to develop a coordinated study of one area might produce more comprehensive and useful results in less time. The experience of developing such a project and producing viable recommendations might set a precedent for future work in other areas. At the beginning of the MHI-MRI initiative, certain geographic regions were identified as having changed more than others. Four bays were selected for baseline studies: Kaneohe Bay on Oahu, Kihei on Maui, and Hilo and Kailua-Kona Bays on Hawaii. Since studies were already in progress in the Hanalei River Estuary, Kauai, this region was to be included in later work. An assessment of community structure is much more feasible within a limited and enclosed area, as opposed to on areas of open coast where immigration and emigration represent substantial elements of community structure.

Cooperative research will be necessary if the MHI-MRI studies are to show that changes in the abundance of Hawaii's coastal resources are attributeable to one factor more than another. Studies focused at the organismal or population levels will rely on information obtained from studies of biomass and community structure. Broad ecological surveys will need to be complimented by research defining the mechanisms by which fishing, human activity, urban and industrial development influence growth, diversity and abundance. It will be difficult for a single study to cover the necessary components of coastal ecology unless cooperative studies are developed.

In designing cooperative work, it is important to give careful consideration to the variables influencing population dynamics. The effort to brainstorm the research question, objectively evaluating whether or not alternative factors affecting population dynamics are being taken into account, is one of the most important tasks of each working group. Any contention of impact indicating the need for management measures which limit the recreational and economic activities of resource users will be tested for ecological "loopholes" in public hearings. Open discussion, in an effort to distinguish the various components affecting community structure and function, will both improve the interaction and cooperation of researchers and help insure that these aspects are adequately addressed. Once the major components of the overall ecological picture have been defined a division of labor will be possible, allowing some researchers to concentrate on physical parameters while others examine growth, diversity, abundance, migration and seasonal variation. As the smaller studies begin to generate useful information, these data should be reintegrated into the broader perspective of community structure and growth. The goal should be to quantify and rank various factors in terms of their impact on the resources in question.

An emphasis should be placed on experimental studies showing the differences in ecological determinants of resource productivity (growth, reproduction and mortality) at sites altered to varying degrees by fishing and development. These studies include experiments which have not necessarily been created by the researcher. An example is a study in progress (Brock-Waikiki) of the variation in community structure resulting from periodic closure of an area of coastline to fishing. A complimentary study could examine the influence of specific population and community structures on resource stability, biomass and productivity through mathematical modelling. Another example would be a study designed to monitor fishing mortality and community structure (or single species abundance, population size-structure, etc.) in distinct locations with similar environmental characteristics. These are different from census and correlative studies, which fail to identify the causes of observed changes in coastal ecosystems (although the latter example would have to be carefully designed in order to avoid this problem).

It is important that MHI-MRI help to develop effective means of monitoring biological variables and environmental parameters in coastal ecosystems and understanding the interactions that determine the effect of fisheries and environmental change on resource productivity, abundance and diversity. This should be done with a sense of realism, by studies designed to produce interpretable results in 5-10 years or less. Otherwise, MHI-MRI will have little useful information to offer as a result of considerable expenditure of time, effort and funding. Since the impact of any factor on coastal resources must be defined in terms of its influence on growth, reproduction and mortality, studies of human-induced environmental changes and those monitoring physical parameters should be supported by concurrent biological studies.

At the same time, it is important to keep abreast of proposed legislation and provide available information in a timely manner. A computerized system exists for tracking bills through the Senate and House. Bills influencing the exploitation and protection of coastal resources should be systematically followed so as to be aware when informed input is needed. Eventually, this process should become less a reaction to introduced measures and more a product of Project initiative toward recommended management policies. Both types of input are dependent upon the development of more complete baseline information.

Some pilot studies are already underway, many of which could be identified as collaborative (contributing) rather than core studies (those producing information critical to the immediate management of MHI coastal resources). Just as research is needed to define trends in abundance and exploitation of coastal resources, many potential topics concerning human-induced environmental changes can be identified. For example, no attempt is being made to evaluate the impacts of hydrocarbons, industrial chemicals and boat traffic in Hawaii's harbors and along her coastline. No study has been proposed to evaluate the effects of reduced freshwater runoff due to irrigation, urban and industrial uses. We are not monitoring the levels or impacts of pesticides or marine debris in our bays and on our coastline. The goals of MHI-MRI as proposed initially are so broad that it would be possible to define an almost limitless number of topics that need to be addressed by research. And yet, the project must begin with the most essential.

Substantial progress has already been made. The development of legislative and public support and funding for such a project is one major accomplishment. However, with such recognition comes responsibility and MHI-MRI must now demonstrate that research can indeed provide the basis for better resource management. Significant interest in and commitment to this effort has been expressed on the part of Hawaii's research community. What remains is to focus this interest, encourage the participation of others and follow through on the projected goals of this important cooperative project.

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APPENDIX 1
State of Hawaii
Department of Land and Natural Resources
Honolulu
DIVISION OF AQUATIC RESOURCES

COMMERCIAL FISH LANDINGS BY SPECIES, STATE OF HAWAII - JANUARY 1989

Sea Landings by Species

SPECIES	LBS. LANDED	LBS. SOLD	VALUE($)
-TUNAS-			
Aku	193,435	189,835	326,530
Yellowfin	145,221	140,674	391,633
Bigeye	118,327	118,315	432,798
Albacore	2,967	2,967	6,196
Kawakawa	1,851	1,363	1,959
Miscellaneous	11	11	8
-SUBTOTAL-	461,812	453,165	1,159,124
-BILLFISHES-			
Blue marlin	54,231	49,774	54,784
Striped marlin	45,976	44,461	65,258
Shortbill spearfish	6,271	5,980	11,186
Black marlin	471	357	604
Sailfish	6,080	6,080	6,187
Swordfish	831	831	3,511
Miscellaneous			
-SUBTOTAL-	113,860	107,483	141,530
-MISC. PELAGIC FISHES-			
Mahimahi	17,538	16,406	61,131
Ono	7,953	7,589	32,105
Kaku	268	162	256
Kamanu	633	575	837
Monchong	664	664	1,488
Opah	6,736	6,736	10,819
Walu	184	184	95
-SUBTOTAL-	33,976	32,316	106,731
-DEEP BOTTOMFISHES-			
Hapuupuu	2,842	2,828	9,350
Kahala	3,678	916	753
Kalekale	1,109	1,073	2,533
Opakapaka	38,008	37,045	154,527
Uku	26,136	24,924	91,520
Ehu	3,276	3,025	11,283
Ulaula (onaga)	10,577	9,992	48,466
Lehi	3,868	3,543	11,726
Ukikiki (gindai)	164	147	452
Taape	1,966	1,815	1,912
Hogo	152	128	371
-SUBTOTAL-	91,776	85,436	332,893
-AKULE/OPELU-			
Akule	44,594	41,051	72,236
Hahalalu	1,279	1,234	2,487
Opelu	44,670	44,057	54,410
Opelu mama	5	5	6
-SUBTOTAL-	90,548	86,347	129,139

SPECIES	LBS. LANDED	LBS. SOLD	VALUE($)
-JACKS-			
Omilu	538	532	1,387
Ulua kihikihi	76	64	111
Butaguchi	2,956	2,949	7,423
Dobe ulua	5	5	5
Menpachi ulua	38	38	45
Papa ulua	1,135	1,117	3,092
White ulua	2,948	2,947	6,877
Ulua/papio	7,988	7,445	15,086
-SUBTOTAL-	15,684	15,097	34,026
-INSHORE FISHES-			
Parrotfishes			
Panuhunuhu	36	36	43
Panunu	29	4	12
Uhu	2,818	2,759	4,492
Goatfishes			
Weke ula	1,330	1,206	3,390
Kumu	932	905	5,283
Moano	434	416	2,217
Weke	2,632	2,431	3,612
Malu	43	43	123
Weke pueo	135	135	34
Moana kali	161	120	968
Surgeonfishes			
Kala	2,263	2,223	2,081
Kole	417	396	641
Maiko	26	26	26
Manini	1,251	1,205	2,309
Naenae	305	305	254
Pakuikui	75	75	89
Pala	69	69	46
Palani	1,019	972	1,159
Pualu	150	150	175
Opelu kala	414	402	324
Damselfishes			
Kupipi	13	13	50
Maomao	23	23	19
Squirrelfishes			
Alaihi	15	15	32
Uu	932	870	2,553
Uukanepou	16	16	55
Wrasses			
Aawa	735	713	678
Hilu	3	3	3
Hinalea	74	57 60	Kupou[illegible]
Laenihi	315	223	708
Poou	65	36	57
Miscellaneous (Ea)	80	80	40
Miscellaneous Inshore Fishes			
Ahaaha	24	14	11
Aholehole	869	713	1,603

SPECIES	LBS. LANDED	LBS. SOLD	VALUE($)
Awa	3	3	6
Aweoweo	276	262	524
Humuhumu	23	20	27
Kawalea	405	371	520
Lae	14	12	10
Moi	408	395	2,249
Mu	27	27	67
Nenue	677	667	666
Nohu	106	101	194
Nunu	10	0	0
Olililepa	36	36	56
Oio	143	87	77
Poopaa	54	50	50
Puhi (white)	6	6	2
Roi	90	88	172

Toau	54	50	113
Uouoa	167	160	307
Wahanui	43	40	42
-SUBTOTAL-	20,442	19,201	38,796
-SHARKS-			
Hammerhead	300	0	0
Mako	1,349	1,349	2,254
Thresher	801	801	735
Miscellaneous	2,122	1,767	1,587
-SUBTOTAL-	4,572	3,917	4,576
-LOBSTERS-			
Ula (spiny)	9,245	9,237	97,323
Ula papapa (slip.)	646	638	5,839
-SUBTOTAL-	9,891	9,875	103,162
-CRABS-			
Kona	281	185	781
Kuahonu	790	782	4,119
Aama	36	36	239
-SUBTOTAL-	1,107	1,003	5,139
-OTHER ANIMALS-			
Hee (octopus)	608	539	1,238
Muhee (squid)	4	4	10
Opihi	560	423	1,390
Wana	28	0	0
Lole	6	6	39
-SUBTOTAL-	1,206	972	2,677
-SEAWEEDS-			
Limu kohu	333	333	2,060
Limu manuaea	176	176	504
Ogo	350	149	380
Miscellaneous	8	3	6
-SUBTOTAL-	867	661	2,950
Miscellaneous	161	161	238
-TOTAL-	845,902	815,634	2,060,981

Pond Landings by Species

SPECIES	LBS. LANDED	LBS. SOLD	VALUE($)
Ulua	116	116	252
Aholehole	171	171	404
Amaama	673	673	2,289
Awa	149	149	270
Awaowa	31	31	31
Kaku	5	5	13
Moi	95	95	327
Oio	190	190	189
Pualu	145	145	134
Summer mullet	26	26	73
Toau	1	1	3
Tilapia	276	276	1,028
Crab (samoan)	9	9	36
Miscellaneous	1,040	1,040	2,564
-TOTAL-	2,927	2,927	7,613
-GRAND TOTAL-	848,829	818,561	2,068,594

Sea Landings by Fishing Method

FISHING METHOD	LBS. LANDED	LBS. SOLD	VALUE($)
Aku Pole & line	181,616	181,616	307,930
Longline	225,109	225,051	661,414
Deepbottom handline	104,582	97,689	361,432
Inshore handline	18,656	17,100	33,787
Ika-shibi, palu-ahi, pelagic drift handline	85,980	83,671	237,381
Trolling	123,425	108,293	209,900
Diving	5,109	4,919	10,131
Net	86,018	82,303	121,112
Trap	12,989	12,986	110,599
Rod & reel (casting, dunking, etc.)	569	538	695
Knife - (opihi & wana)	559	394	1,317
Handpick - (limu & pipipi)	963	757	3,477
Miscellaneous	327	317	1,799
-TOTAL-	845,902	815,634	2,060,974

Sea Landings by Island

ISLAND	LBS. LANDED	LBS. SOLD	VALUE($)
Oahu	541,968	534,119	1,436,713
Hawaii	183,369	174,207	368,069
Maui	58,939	52,535	116,047
Kauai & Niihau	55,553	49,125	129,158
Molokai	5,510	5,221	10,171
Lanai	563	427	819
-STATE TOTAL-	845,902	815,634	2,060,977

Sea Landings by Major Catch Area

AREA (area catch code)	LBS. LANDED	LBS. LANDED	VALUE($)
Main Hawaiian Islands (refer to Fisheries Chart No. 2)			
Kaula (508,528)	4,431	4,431	13,141
N. Kauai-Niihau (506,526,502, 522,503,523)	9,271	7,597	18,655
Kaulakahi Channel (505,525, 501,521)	5,985	5,128	13,164
Kauai Channel (500,520,504, 524,527)	35,659	31,762	84,504
Waianae (402,422,403,423)	66,082	64,334	143,222
Ewa-Pearl Harbor (401,421)	12,291	11,555	30,624
Ala Moana (400,420)	76,907	76,864	142,090
Diamondhead-Kokohead (409,429)	6,452	6,048	21,076
Waimanalo (408,428)	14,401	14,202	24,302
Punaluu-Kaneohe (407,427)	17,932	16,808	35,370
Laie (406,426)	45,109	44,774	71,682
N.W. Oahu (404,424)	8,151	7,425	19,146
Waialua-Kahuku (405,425)	10,652	10,469	22,103
Penguin Bank (311,331)	34,912	33,261	124,663
Hana,Maui-W. Molokai (312,332, 313,333,302,322,303,323)	8,070	7,087	22,122
Kalohi & Auau Channels 310,314,321,309,301)	24,136	22,694	44,450
Alalakeiki Channel (300,320)	25,824	22,708	45,468
West Lanai-Kahoolawe (308,328,307,327)	11,696	10,526	27,965
Alenuihaha Channel (306,326, 305,325,304,324)	6,815	6,662	18,158
Kona (100,120,101,121,102,122)	101,307	94,914	140,619
Kau (107,127,108,128)	22,862	21,512	60,131

Sea Landings by Major Catch Area (Cont.)

AREA (area catch code)	LBS. LANDED	LBS. LANDED	VALUE($)
Kalapana-Hilo (105,125,106,126)	65,108	64,001	195,935
Laupahoehoe-Kohala (103,123, 104,124)	6,047	5,826	26,950
Other (all other area codes from Fisheries Chart No. 2 not listed above)	133,111	132,355	404,044

-SUBTOTAL-	753,211	722,943	1,749,584
Northwestern Hawaiian Islands (refer to Fisheries Chart No. 3)			
Nihoa (1039,1050,1060)	3,170	3,170	9,530
Necker (1139,1140)	3,410	3,410	13,246
French Frigate Shoals (1239)	5,124	5,124	55,181
Maro Reef (1739)	4,021	4,021	43,311
Other	1,224	1,224	4,169
-SUBTOTAL-	16,949	16,949	125,437
Other areas (not in Fisheries Charts 2 & 3)	75,742	75,742	185,953
-TOTAL-	845,902	815,634	2,060,974

Sea Species Commonly Caught Near Buoys (Lbs. Landed)

Hawaii Buoys

SPECIES	B	C	E	F	GOTEC 343	GOTEC 3	TT	UU	VV	XX	ZZ
Aku	18	-	92	87	343	3	4	47	-	21	-
Yellowfin	1,062	-	137	713	1,009	447	245	82	50	166	97
Kawakawa	-	-	-	-	3	-	-	-	-	-	-
Blue marlin	796	138	-	1,575	-	1,322	119	-	-	1,426	-
Striped marlin	-	-	-	328	76	-	-	-	-	102	-
Shortbill spearfish	-	-	-	136	-	-	-	-	-	-	-
Mahimahi	39	32	69	168	26	171	231	-	13	244	64
Ono	15	-	-	-	-	-	-	-	-	-	-
Mano	-	-	-	-	-	123	-	-	-	-	-
-TOTAL-	1,930	170	298	3,007	1,457	2,066	599	129	63	1,959	161

Oahu Buoys

SPECIES	HH	J	LL	MM	NN	R	S	U	V	W
Aku	2,180	230	192	1,326	-	997	38	1,464	-	479
Yellowfin	2,501	176	-	543	-	3,185	10	728	-	326
Kawakawa	-	-	-	-	-	320	-	-	-	-
Blue marlin	166	614	336	-	-	1,071	-	-	-	-
Striped marlin	80	-	-	181	-	36	-	-	-	-
Shortbill spearfish	-	35	43	-	-	72	-	-	-	-
Mahimahi	94	160	498	334	6	38	-	100	-	216
Ono	-	30	41	46	-	38	-	-	-	-
Opelu	-	-	-	-	-	-	-	-	121	-
-TOTAL-	5,021	1,245	1,110	2,430	6	5,757	48	2,292	121	1,021

Kauai Buoys

SPECIES	Z	AA	BB	EK	PP	WK
Aku	-	92	26	34	107	46
Yellowfin	1,125	5,196	-	55	1,366	1,082
Blue marlin	-	123	-	-	110	-
Mahimahi	20	171	-	-	58	-
Ono	-	39	-	30	-	-
-TOTAL-	1,145	5,621	26	119	1,641	1,128

Maui, Kahoolawe, Lanai, and Molokai Buoys

SPECIES	I	K	Q	DD
Aku	-	6	137	17
Yellowfin	100	-	712	-
Kawakawa	-	28	-	-
Striped marlin	-	1,233	-	63
Mahimahi	47	69	478	91
Ono	-	-	28	-
Mano	12	-	110	-
-TOTAL-	159	1,336	1,465	171

APPENDIX 2 - HAWAII'S COMMERCIAL FISHERIES BY GEARTYPE & SPECIES

HOOK & LINE FISHERIES:

Geartype	Species Complex*
Aku boat, Pole & Line	Aku, Kamano, Kawakawa, Mahimahi
Ahi boat, Flagline, Longline, Kaka	Ahi (general), Bigeye, Broadbill, Kaku, Mahimahi, Mano, Mano Kihikihi, Monchong, Mola Mola, Marlin (Striped/Blue/White/ Black/Silver), Ono (Wahoo), Opah, Sailfish, Sharks (various) Shortnosed Spearfish, Tombo, Walu (smooth skin).
Deep Sea Handline, Bottom Handline	Aji=Akule, Butaguchi, Dobe, Ehu, Gindai, Gunkan, Hapuupuu, Hauliuli, Hogo, Kahala, Kaku, Kalekale, Kawelea, Kagami, Lehi, Monchong, Muhee, Omilu, Onaga, Opakapaka, Opelu Kala, Opelu Mama, Papa, Papio, Puhi, Saba, Sharks (various), Taape, Uku, W/B Ulua, Weke-ula
Inshore Handline	Ahaaha, Akule, Alaihi, Awa, Awaawa, Aweoweo, Ea, Hahalalu, Wahanui, He'e (octopus), Hinalea, Humuhumu, Kawelea, Lae, Laenihi, Makiawa, Malu, Moana, Moana Kali, Mu, Nenue, Olililepa, Oio, Omaka, Opelu, Papa, Papio, Poi'ou, Poopaa, Pualu, Rays, Roi, Saba, Taape, Toau, Upapalu, Uu, Uukanipo, Walu (inshore species, spiney skin), Weke-ula
Light Tackle, Casting	Aweoweo, Kaku, Kupoupou, Maomao, Moana, Moi, Oio, Omaka, Omilu, Panuhunuhu, Papio, Pualu, Taape, Tilapia, Toau, Weke
Kaka Line, Set Line (bottom Longline)	Oopuhue, Kagami
Trolling (with lures live bait)	Ahi, Aku, Dogtooth Tuna, Kaku, Kamano, or Kawakawa, Keokeo, Lae, Mahimahi, Marlin (Striped/Blue/W/B/Silver), Omilu, Ono, Sailfish, Short-nosed Spearfish, Ulua (W/B)
Ikashibi/Palu-ahi/ Drift or Pelagic Handline	Ahi (general), Bigeye, Broadbill, Mahimahi, Marlin (Striped/Blue), Ono (night), Tombo

*Note: A listing of scientific names for these species will be provided.

TRAP FISHERIES:

Geartype	Species Complex
Crab Trap	Blue Pincher, Hawaiian Red, Kuahonu, Kona, Moala, Papai, Stone Crab, Samoan, White, misc.
Shrimp Trap	*Heterocarpus laevigatus*, *H. ensifer*
Fish Trap	Alaihi, Ea, Kagami, Kumu, Lauwiliwili, Maiko, Maikoiko, Malu, Manini, Moana, Naenae, Nunu, Omilu, Onaga, Opakapaka, Opelu Kala, Rays (various), Pala, Palani, Pualu, Puhi, Puhi, Taape, Toau, Upapalu, Uu, Uukanipo, Weke, Weke-Ula (Moelua)
Lobster Trap	Spiny & Slipper Lobsters
Trap (other)	He'e (octopus)

DIVING & MANUAL FISHERIES:

Knife	Opihi, Wana
Diving w/spear	Aholehole, Alaihi, Aweoweo, Ea, Wahanui, He'e (octopus), Hilu, Kala, Kole, Kumu, Kupipi, Maiii, Maiko, Maikoiko, Malu, Manini, Maomao, Moana, Moana Kali, Mu, Naenae, Nenue, Nohu, Olililepa, Omilu, Opelu Kala, Opule, Pakii, Pakuikui, Palani, Panuhunuhu, Panunu, Papa, Poi'ou, Poopaa, Pualu, Puhi, Roi, Toau, Uhu, Ulua W/B, Uu, Uukanipo
Diving w/hand (or wading)	Crustaceans: Hawaiian Red Crab, Lobsters, Moala Crab, Spiney Lobster
	Mollusks: He'e, Hihiwai (FW), Opihi (SW), Pipipi, Pupu
	Echinoderms: Ina, Sea Urchin, Sea Cucumber
	Various algae (limu): Kohu, Ogo, Manauea, Wawaeiole & misc.

NET FISHERIES:

Geartype	Species Complex
Net Unclassified (including): - Weke Net - Scoop Net	Kumu, Moelua (Weke Ula), Palani, Weke Iheihe, Koha Crab, Kuahonu Crab, Malolo, Opae (Shrimps), Samoan Crab, Squids, White Crab
Opelu Net	Opelu
Gill Net, Fence, Lay, Cross	Ahaaha, Aholehole, Akule, Amaama, Awa, Awaawa, Ea, Hilu, Iheihe, Kala, Kumu, Lae, Makiawa, Malu, Manini, Maomao, Moana, Moi, Oio, Omaka, Oopuhue, Palani, Panuhunuhu, Panunu, Paopao, Taape, Tilapia, Uhu, Uu
Seine Inshore (Hukilau/Akule/Bag Net) Drag Net, Bull Pen	Akule, Awa, Kaku, Kagami, Lae, Oio, Omilu, Oopuhue, Rays, Toau, Ulua W/B, Weke
Lobster Net	Spiny & Slipper Lobsters
Crab Net	Hawaiian Red, Kuahonu, Moala, Koha, Kona, Papai, Samoan, Stone Crab, White, misc.
Throw Net, Cast Net	Aholehole, Amaama, Kala, Kupipi, Maiii, Manini, Moi, Nenue, Opule, Surf Maiko, Uhu, Uouoa
Bait Net	Herring, Iao, Nehu, Piha, Sardines
Hawaiian Purse Seine, Surround	Akule, Amaama, Awa, Aweoweo, Hahalalu, Kala, Manini, Moi, Oio, Taape
AQUACULTURE:	
Traditional Pond	Amaama, Awa, Olepe (Clam), Opuhue, Paopao, Tilapia
Other Aquaculture	Amaama, Awa, Macrobrachium, Moi, various Penaeid Shrimp

FIGURE 1A:
OVERALL PLAN FOR A 5-10 YEAR MHI-MRI PROJECT IN ACCORDANCE WITH ESTABLISHED GOALS

TIME FRAME (years)	GENERAL PHASE OF DEVELOPMENT
1987 1988 1989	PROJECT INITIATIVE GENERAL PLANNING AND DISCUSSION DEVELOPMENT AND FUNDING
	********** BEGINNING OF 5-10 YEAR COUNTDOWN
1990	INITIAL RESEARCH ACTIVITIES AND SPECIFIC PLANNING BEGINNING OF GEOGRAPHIC DATABASE DEVELOPMENT (GENERAL INFORMATION FIRST: DISTRIBUTION, ABUNDANCE, AREAS OF IMPACT FISHING)
1991	DATA COLLECTION AND SYNTHESIS (REVIEW LITERATURE, EXISTING FISHERIES DATA AND REGULATIONS) (NOTE XVII PACIFIC SCIENCE CONGRESS: POTENTIAL FOR BROAD-BASED CONFERENCE/DISCUSSION OF GOALS & METHODS, SOME PRESENTATION OF RESULTS)
1992	CONSOLIDATE GEOGRAPHIC DATABASE (AREAS AND AMOUNTS OF IMPACTS FISHERIES AND OTHERS) PRESENT SOME RESULTS TO RESOURCE ADMINISTRATORS: SYMPOSIUM (TRENDS RESOURCE USE AND ABUNDANCE: EVALUATION SPECIFIC PRIORITIES)
1993	STUDIES POPULATION IMPACTS INTEGRATED WITH GEOGRAPHIC DATABASE DEVELOPMENT. ESTIMATES FISHING & "NATURAL" MORTALITY (INCLUDING OTHER HUMAN)
1994	REVIEW AND EVALUATION SYMPOSIUM (RESEARCHERS, ADMINISTRATORS & ENFORCEMENT) : WHAT CAN & SHOULD BE DONE TO MANAGE MHI COASTAL MARINE RESOURCES?
	********** INITIATE CYCLES OF MONITORING, REEVALUATION AND ADJUSTMENT OF MANAGEMENT MEASURES
1995	MONITORING. FURTHER DEVELOPMENT MANAGEMENT PLAN. SIMPLE GEOGRAPHIC-BASED ECOSYSTEM MODELLING
1996	REVIEW MHI COASTAL RESOURCE MANAGEMENT PLAN SYMPOSIUM (RESEARCHERS, ADMINISTRATORS, ENFORCEMENT, FISHERS & THE PUBLIC): FEEDBACK REGARDING FIRST YEAR RESULTS
1997	CONTINUE MONITORING MANAGEMENT RESULTS
1998	REEVALUATION RESULTS MHI COASTAL RESOURCE MANAGEMENT PLAN. SYMPOSIUM/PUBLIC FORUM (ALL CONCERNED PARTIES)
1999	PRESENT LONGTERM MANAGEMENT RECOMMENDATIONS (INCLUDING METHODS OF CONTINUOUS MONITORING & REASSESSMENT)
2000	REEVALUATION & ASSESSMENT OF WHETHER OR NOT RESULTS MHI COASTAL MANAGEMENT PLAN ARE SATISFACTORY: RECOMMENDATIONS FOR THE FUTURE PUBLIC FORUM: HOW TO ENSURE THAT ADEQUATE MANAGEMENT/LEGISLATION EXISTS AND FUNCTIONS

FIGURE 1B: SPECIFIC OBJECTIVES AND ACTIVITIES FOR A 5-10 YEAR MHI-MRI PROJECT IN ACCORDANCE WITH ESTABLISHED GOALS

YEAR	OBJECTIVES AND ACTIVITIES
1987 1988 1989	IDENTIFICATION OF THE PROBLEM: DISCUSSION OF GENERAL GOALS AMONG RESEARCHERS, STATE AND FEDERAL ORGANIZATIONS SURVEY OF RESEARCHER AND PUBLIC CONCERNS & PUBLICATION OF RECOMMENDATIONS FOR A 5-YEAR MHI-MRI STUDY PROJECT SUBMITTED TO DLNR BOARD AND LEGISLATURE. FUNDING AND CONTRACTS FOR PILOT STUDIES & PROJECT COORDINATOR. OBTAINED GENERAL AGREEMENT AND COOPERATION OF HAWAII FISHING AND RESEARCH ORGANIZATIONS. ESTABLISHED MHI-MRI COUNCIL.
1990	I) MOST IMPORTANT PRIORITY! DEVELOP CONSENSUS CONCERNING OVERALL PROJECT PLAN : ELABORATE GENERAL GOALS INTO SPECIFIC PRIORITIES A) IDENTIFY BOUNDARIES AND DIRECTION (GEOGRAPHIC, BATHYMETRIC, SUBSAMPLE OF HABITATS, FIRST LEVEL SELECTION OF SPECIES AND FISHERIES) B) ASSIGN IMMEDIATE PRIORITIES C) AGREE ON GUIDELINES FOR METHODOLOGY D) DEVELOP AND CIRCULATE A CALL FOR PROPOSALS FOR NEXT BIENNIUM II) CONTINUE PILOT STUDIES III) WORK TOWARDS GENERAL GOALS ESTABLISHED IN RECOMMENDATIONS FOR A 5-YEAR MHI-MR INVESTIGATION (Pooley et al., 1987):

1) DETERMINE LEVELS OF EXPLOITATION OF LIVING MARINE RESOURCES

YEAR				
1990	EVALUATE COMMERCIAL LANDINGS DATABASE 1ST ORDER ESTIMATE TRENDS IN CATCH	CREEL SURVEYS: ESTIMATE RE-CREATIONAL CATCH & EFFORT	EVALUATE HISTORICAL TRENDS IN FISHING EF-FORT/POWER	EVALUATE HISTORICAL TRENDS IN PRICE AND PREFERENCE
1991	USE RATIO RECREATIONAL:COMMERCIAL CATCH - ESTIMATE TOTAL CATCH BY SPECIES & FISHERY			
1992	USE CATCH & EFFORT DATA: ESTIMATE CPUE 1990-1992: GRADUALLY DEVELOP ESTIMATES OF PAST CATCH & CPUE			
1993	INCLUDE INFORMATION ON MARKET TRENDS: ANSWER QUESTION WHETHER APPARENT DECLINE IN CATCH DUE TO DECLINE IN ABUNDANCE OR TO CHANGING MARKET PREFERENCES (FOR TARGET SPECIES/FISHERIES)			
1994	DEVELOP SURPLUS PRODUCTION ESTIMATES OF RECOMMENDABLE FISHERIES YIELDS (MSY/OSY)			

2) DEVELOP AN UNDERSTANDING OF BIOLOGY, DISTRIBUTION & ABUNDANCE & DETERMINE IMPACT HUMAN-INDUCED & ENVIRONMENTAL CHANGE

INITIALIZE GEO-GRAPHIC DATA-BASE (GIS): DIGITIZE MAPS SUBSTRATES DEPTH PROFILES REGIONAL CATCH REPORTS NUTRIENTS FISHING FLEETS & CPUE LANDBASED WATER TOXICS	PILOT STUDIES SELECT REGIONS SURVEYS INDICATE MOST CHANGED: KANEOHE BAY HILO BAY KAILUA-KONA KIHEI, MAUI HANALEI, KAUAI	ESTIMATE POPULATION PARAMETERS: *MORTALITY FISHING "NATURAL" LENGTH-WT GROWTH REPRODUCTION SEASONS AREAS MIN. SIZE FECUNDITY METHODS: LITERATURE CREEL SURVEYS ANALYZE CPUE BY REGION	DEVELOP & INITIATE ECOLOGICAL MONITORING: PHYSICAL BIOLOGICAL -PRINCIPLE RESOURCES IN ORDER OF PRIORITY INCLUDE INFO IN GIS AS DEVELOPED

ASSESSMENT IMPORTANCE/IMPACTS FISHERIES & ENVIRONMENTAL CHANGE

3) DEVELOP MANAGEMENT STRATEGIES TO CONSERVE & ENHANCE RESOURCES

REVIEW EXISTING FISHERIES REGULA-TIONS REGARDING: BIOLOGICAL BASIS SEASONAL COVERAGE MINIMUM SIZE FOR REPRODUCTION EXISTENCE QUOTAS/ & BAG LIMITS RESOURCE COVERAGE GEOGRAPHIC OVERLAP APPROPRIATENESS/ ENFORCEABILITY APPARENT IMPACT	TRACK & PROVIDE NEEDED INPUT ON LEGISLATIVE PRO-POSALS, BILLS... CIRCULATE UPDAT-ED SCHEDULE & ISSUES EACH LEG-ISLATIVE SESSION TO PARTICIPANTS MHI-MRI
IDENTIFY AREAS NEEDING IMPROVEMENT	IMPROVED DATA-BASE WILL ALLOW MRI TO BEGIN TO RECOMMEND BETTER MANAGEMENT MEASURES

1994: BEGIN DEVELOPMENT OF PRELIMINARY MANAGEMENT MEASURES: SET EXPERIMENTAL QUOTAS & SEASONAL CLOSURES BASED ON BIOMASS OR NUMBERS
ENSURE RECOMMENDATIONS FOR MINIMUM SIZE LIMITS FOR PRINCIPLE SPECIES/FISHERIES

1995: BEGIN GEOGRAPHIC-BASED SIMULATION OF EFFECTS OF FISHERIES MANAGEMENT POLICIES (SIMPLEST FIRST):
i.e. EFFECTS - COMPLETE CLOSURE (MCLD)
- SEASONAL OR PERIODIC CLOSURES (INCORPORATE INFORMATION FROM FIELD
- QUOTAS (REGIONAL, IF SUCH REGULATIONS CAN BE ENFORCED; OTHERWISE JUST BIOMASS/NUMBER

GUIDELINES FOR DEVELOPMENT OF REGIONAL MANAGEMENT PLANS:
1) ENUMERATE SPECIFIC BIOLOGICAL MEASURES OF RESOURCE MAINTENANCE.
2) DEVISE PROGRAM OF ONGOING MONITORING BY A) INDICATOR SPECIES
B) BIOMASS (PER UNIT AREA)
C) DIVERSITY
D) SIZE OF REPRODUCTIVE STOCK SIZE
3) SPECIFY HOW TO DETECT UNDESIREABLE IMPACTS (i.e. SET MINIMUM STANDARDS FOR THE ABOVE #2)
4) SUGGEST PRELIMINARY QUOTAS, SEASONAL CLOSURES OR MCLD'S FOR PRINCIPLE RESOURCES.
5) INITIATE SIMULATION OF EFFECTS MANAGEMENT USING GEOGRAPHIC DATABASE (BEGINNING WITH SIMPLE PROJECTIONS)

NOTES: IT SHOULD BE CLEAR THAT THIS IS AN EXTENSIVE PROJECT & CAN'T BE CARRIED OUT FOR ALL OF HAWAII'S COASTAL FAUNA. THEREFORE, IT WILL BE IMPORTANT TO TARGET THE MOST IMPORTANT SPECIES OR FISHERIES FOR STUDY IN THE EARLY STAGES. THIS CAN FIRST BE DONE SOLELY ON THE BASIS OF TRENDS IN COMMERCIAL LANDINGS & SPECIES IDENTIFIED IN 1987-88 SURVEYS. LATER INCLUDE: GOOD INDICATOR SPECIES & THOSE SHOWN BY VARIOUS MEASURES TO BE OVEREXPLOITED. ONLY 5 YEARS OF ACTIVITIES ARE SPECIFIED. SUBSEQUENT YEARS WILL BE NEEDED TO IMPROVE AND IMPLEMENT MANAGEMENT MEASURES.