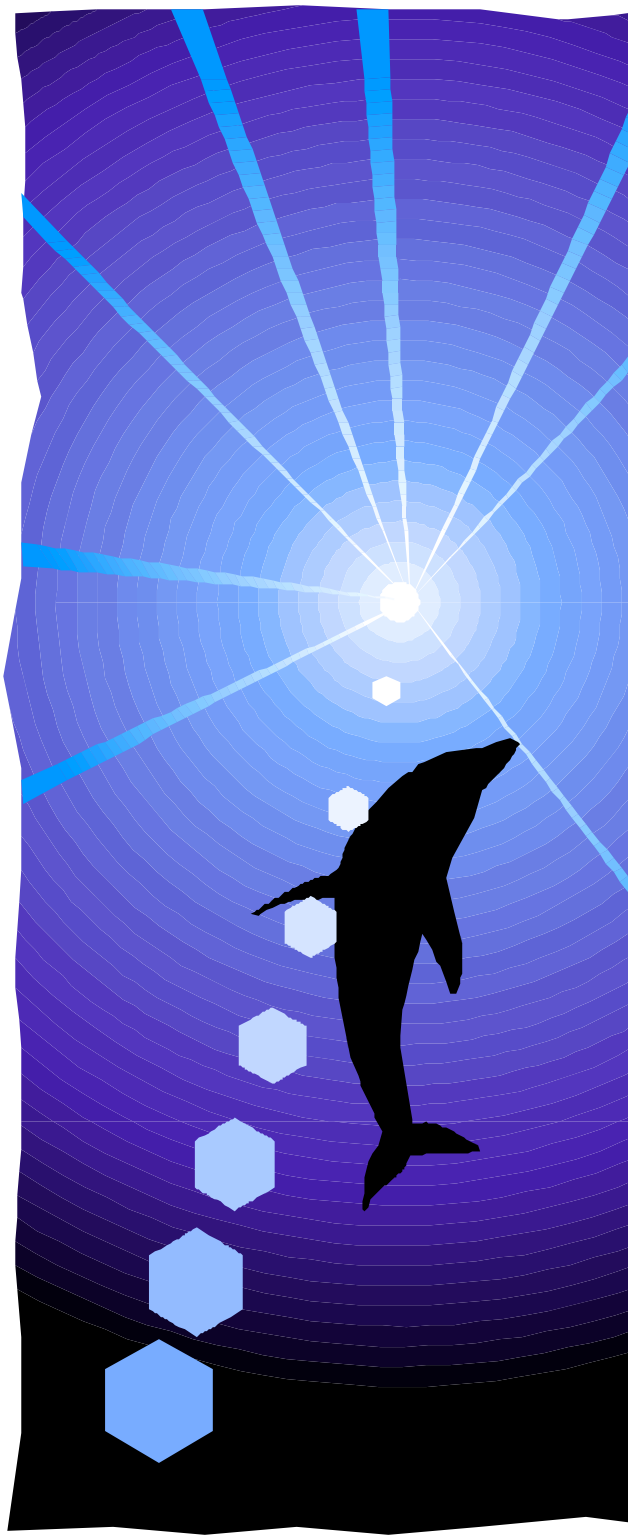

LONG TERM MARINE MONITORING PLAN FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

AUGUST 1996

DIVISION OF ENVIRONMENTAL QUALITY

COASTAL RESOURCES MANAGEMENT DIVISION

DIVISION OF FISH AND WILDLIFE

NORTHERN MARIANAS COLLEGE

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(A) Introduction

The Commonwealth of the Northern Mariana Islands (CNMI) has undergone significant change over the years. Agricultural development and World War II battles have eliminated most of the natural vegetation. Homesteads and booming urban areas, coupled with inadequate sewage systems, have resulted in extensive concentrations of septic tank systems. Rapid development has resulted in a change from crushed coral roads to four-lane highways; from relatively few tourist facilities to five star hotels, resorts, and golf courses. Although much of this development has been a boost to the CNMI's economy, the culture, people, and islands will inevitably face adverse impacts. However, the degree of this potential damage from continuous change may be minimized if we plan properly to manage our resources.

The CNMI Division of Environmental Quality (DEQ), CNMI Coastal Resource Management Division (CRM), Northern Marianas College (NMC), and CNMI Division of Fish and Wildlife (DFW) share the goal of developing and implementing a long-term marine monitoring program. The goal of this marine monitoring program is to minimize the adverse effects of development and daily use of our islands' resources on the marine environment by regularly monitoring nearshore waters. Regular monitoring can detect problems early on and determine which management measures work and which do not. Once a problem is detected, the CNMI government can insure action steps are taken early to remedy the problem.

As noted by the National Research Council in *Managing Troubled Waters, The Role of Marine Environmental Monitoring*, and described in the *West Hawaii Coastal Monitoring Program: Monitoring Protocol Guidelines*, monitoring the marine environment is valuable for the following reasons:

- Monitoring can describe nearshore ecosystems and show how they are affected by human activity. Monitoring therefore allows environmental agencies to set priorities and to assess the potential effects of *status quo* and trends.
- Environmental managers can use monitoring information as their scientific rationale for setting environmental quality standards.
- Monitoring data are essential for quantitative predictive models, which are important when evaluating, developing, and selecting environmental management strategies.
- Monitoring studies can be used to evaluate pollution abatement actions.
- Monitoring can detect problems early on, allowing for lower-cost solutions to environmental problems.
- Monitoring determines compliance with conditions set forth in discharge and other permits.

Initially, the marine monitoring program will focus on determining the effects of nonpoint source pollution on the nearshore environment. When monitoring the effects of nonpoint source pollution, we are also likely to detect natural changes, changes caused

by point source pollution, and other problems in the environment. This program is flexible and adaptable and other focuses may be added as the program evolves. The monitoring studies will attempt to distinguish anthropogenic impacts on the reef from natural variability.

The 1996/97 Lau Lau Bay Watershed Nonpoint Source Pollution Protection Program is the pilot project for this marine monitoring program. Procedures and methods developed for that project will serve as "field tests" for this CNMI-wide marine monitoring program. This plan will be revised after the data and results from the Lau Lau Bay project have been fully analyzed.

Upland monitoring will be incorporated into this plan as resources and training opportunities arise. These studies will become an essential component of the marine monitoring program in an attempt to correlate changes in the reef to upland activities. Management measures implemented under Section 6217 of the Coastal Zone Act Reauthoization Amendments of 1990 will be tracked by the marine monitoring team simultaneously with water quality. Tracking management measures will provide the necessary information to determine whether pollution controls have been adequately implemented, operated, and maintained.

Most of the concepts behind this long term marine monitoring plan are based on previous work described in the following reports and studies: Pring (1989), CNMI Marine Water Quality Monitoring Strategy (1988), The Marine Laboratory University of Guam Studies (1992), Quinn and Tomokane (1996), Oliver, et. al. (1995), and English, et. al. (1994). (See Part E for a complete list of references). This plan builds on the recommendations given in the previous two CNMI marine monitoring plans (Pring, and Quinn and Tomokane), but the intent of this plan is to develop a monitoring program that requires minimal resources and can be implemented by current agency personnel without extensive training. In meeting these two requirements, it is hoped that this marine monitoring program will become an established and continuous program of all involved agencies.

(B) Primary Objectives

- To establish a baseline database of nearshore conditions so that changes in the marine environment can be qualified and quantified.

- To monitor and record changes over time to the nearshore environment.

- To correlate changes in the nearshore environment with upland events, particularly those that cause nonpoint source pollution.

- To establish a trigger mechanism to respond to changes in a timely manner.

- To enable resource managers, political decision makers, and the general public to plan and make informed decisions pertaining to our coastal resources, based on the

results of the surveys, but incorporating the concepts of sustainable development, environmental sustainability, and limits of acceptable change.

(C) Plan Coordination

- Following guidance from an interagency memorandum of understanding (to be developed), the Division of Environmental Quality, Coastal Resources Management Division, Northern Marianas College, and Division of Fish and Wildlife will establish an interagency marine monitoring team. This team will be responsible for the marine monitoring program. Members of the team will be appointed by their respective agency director. Roles and responsibilities of each agency will be identified by the team.

- The reasoning behind creating the marine monitoring team is that this multi-agency team will be capable of conducting more and higher quality studies than any one agency could accomplish alone.

- All members of the team are required to complete the Scientific Diver Certificate Program at NMC, or have equivalent training in SCUBA diving, biology, and surveying techniques.

- No single agency is responsible for coordinating or funding the daily operations of the marine monitoring team, but all agencies will work together to insure the program is viable. When an agency wishes to use the team to conduct a specific project not specified in this plan, that agency will then be responsible for coordinating and funding the team's participation.

- The marine monitoring team will implement and continually develop this marine monitoring program. Training opportunities will continuously be afforded to the team so the members can keep their skills current and upgrade their certifications.

- Members of the marine monitoring team will be cross-trained in all areas of the marine monitoring program.

- The established Department of Lands and Natural Resources Watershed Group may assist the marine monitoring team by providing advice and solutions to problems that are the result of upland activities.

- All major coastal development projects, private and government, should be required to design and implement a comprehensive, site-specific marine monitoring program as a part of their permit conditions, with the intent of limiting the effect of nonpoint source pollution on the marine environment. The permit applicants may follow the basic protocols set forth in this plan and must work with the marine monitoring team when developing their marine monitoring plan. When too many discrete activities are occurring, the government will conduct the monitoring on a shared cost program

with the developers.

(D) Definition of terms

Ambient conditions - conditions that would occur if the waters were not influenced by immediately adjacent activities.

Beach - the zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach is the mean low water line.

BOD - Biochemical oxygen demand; the quantity of dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter and oxidizable inorganic matter by aerobic biological action.

Commonwealth of the Northern Mariana Islands (CNMI) - the fourteen northernmost islands of the Marianas Island chain and the surrounding waters out to the Exclusive Economic Zone (EEZ).

Cumulative effect - the impact on the environment that results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of which agency or person undertakes such action.

Ecosystem - the interacting system of a biological community and its non-living environmental surroundings.

Fecal coliform - bacteria present in mammalian feces, used as in indicator of the presence of human feces, bacteria, viruses, and pathogens in the water column.

Nearshore environment - the environment from the shoreline to the 20 meter depth contour. This area includes most of the CNMI's coral reefs and is most likely to be influenced by anthropogenic actions.

Nonpoint source pollution - pollution of our waters caused by rainfall moving over and through the ground.

Nutrient transformers - biological organisms, usually plants, that remove nutrients from water and incorporate them into tissue matter.

Nutrients - elements, or compounds, essential as raw materials for organism growth and development, such as carbon, nitrogen, and phosphorous.

Pollutant - dredged spoil; solid waste; incinerator residue; sewage; garbage; sewage sludge; munitions; chemical wastes; biological materials; radioactive materials; heat; wrecked or discarded equipment; rock; sand; cellar dirt; and industrial, municipal, and

agricultural waste discharged into water (Section 502(6) of The Clean Water Act as amended by the Water Quality Act of 1987, Pub. L. 100-4).

Runoff - the part of precipitation that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Sample - a small part of anything or one of a number, intended to show the quality, style, or nature of the whole.

Sediment - finely divided solids material that settles to the bottom or is temporarily suspended in the water.

Surface water - all water whose surface is exposed to the atmosphere.

Suspended solids - solid materials that remain suspended in the water column.

Turbidity - a cloudy condition in water due to suspended silt or organic matter.

Watershed - the land area that drains into a receiving water body.

(E) Applicable laws, rules, regulations, and environmental protection measures

CNMI Environmental Protection Act of 1982, Public Law 3-23.

CNMI Ground Water Management and Protection Act of 1988, Public Law 6-12.

CNMI Solid Waste Management Act of 1989, Public Law 6-30.

CNMI Water Quality Standards .

CNMI Drinking Water Regulations.

CNMI Earthmoving and Erosion Control Regulations.

CNMI Pesticide Regulations.

CNMI Individual Wastewater Disposal Regulations.

CNMI Coastal Resources Rules and Regulations of 1990.

CNMI Submerged Lands Act.

National Environmental Policy Act (NEPA) of 1969: Public Law 91-190: 42 USC 4321-4347.

Rivers and Harbors Act of 1899: 33 USC 401-687: 30 Stat. 1151.

Clean Water Act of 1990 (Federal Water Pollution Control Act), Public Law 92-500, as amended: 33 USC 125 *et seq*.

Coastal Zone Management Act of 1972: PL 92-585 as amended, 16 USC 1451-1464.

Endangered Species Act of 1973: PL 92-205 as amended, 16 USC 1531 *et seq*.

Marine Mammal Protection Act of 1972 as amended: 16 USC 1361 *et seq*.

Migratory Bird Treaty Act, Revised No. 1978: 16 USC 703-711.

Magnuson Fishery Conservation and Management Act: 16 USC 1801 *et seq*.

Marine Protection, Research and Sanctuaries Act: 33 USC 1401 *et seq*.

Marine Plastic Pollution, Research and Control Act of 1987: PL 100-200.

All Federal Implementing Regulations applicable to above listed Federal Acts.

(F) Protocol

The five major components of the marine monitoring program are: water quality, general biota and coral surveys, data management, reporting, and action. The water quality studies will detect changes in the water column of the nearshore environment, such as increased concentration of nutrients or high levels of fecal coliform. The general biota and coral surveys will monitor changes in the biological make-up of nearshore ecosystems. The data management component of the marine monitoring program will store the data collected in the studies and surveys for future comparisons and qualitatively and quantitatively analyze the data. These analyses will show if changes in the nearshore environment are taking place and will attempt to correlate these changes to anthropogenic or natural events. A regular reporting scheme will provide opportunities for government agencies and the public to use the data to make informed decisions concerning development practices and resource use. Action triggering will insure that an appropriate agency response occurs to solve the problem detected in the monitoring program.

Initially, the marine monitoring team will select four permanent monitoring sites for Saipan, two for Tinian, and two for Rota, with the potential to add more sites as the monitoring program becomes established. These eight monitoring sites will serve as representatives of larger coastal areas and habitats (i.e., N, S, E, W; lagoon, barrier reef; etc.). In addition, the Division of Environmental Quality laboratory will continue to regularly monitor water quality at the 77 established marine sites.

The monitoring methods used in this program were selected because they use inexpensive and accessible equipment, require minimal expertise, and involve widely

accepted protocols useful for comparing data on a regional scale. The parameters to be monitored relate to applicable laws, rules, regulations, and publicly acceptable environmental conditions.

The Division of Environmental Quality and the Northern Marianas College developing SCUBA diving standards to be used in the marine monitoring program. Until these standards are developed and approved by all involved agency leaders, the marine monitoring team will follow the basic policies and procedures outlined in the University of Guam, Marine Laboratories *Standards for Scientific Diving Certification and Operation of Scientific Diving Program* (1993).

1. WATER QUALITY

Good water quality (within a narrow range of environmental conditions and with limited nutrients, contaminants, and sediments) is essential for the long term growth and survival of coral reefs. Therefore, water quality is an essential parameter to be measured by any long-term marine monitoring program in a tropical environment. In order to correlate natural or human-induced events to changes in the nearshore environment, it is crucial that we know the state of the waters upon which our resources depend.

Each water quality testing procedure is briefly described below. A more complete description of each methodology can be found in the DEQ Water Quality Quality Assurance Plan (1993), the DEQ Marine Monitoring Quality Assurance Plan (1996), or other listed reference.

A. **Salinity, temperature, dissolved oxygen, turbidity, pH, and fecal coliform** (DEQ Water Quality Quality Assurance Plan 1993).

Salinity, temperature, dissolved oxygen, turbidity, pH, and fecal coliform are widely accepted parameters of marine water quality. These parameters can be used to characterize a specific site and to show changes in the nearshore environment over time. These tests are relatively easy and inexpensive to perform and have been a part of DEQ's marine water quality monitoring program since 1984. Acquiring and analyzing this baseline data is an essential first step of the marine monitoring program.

Water quality is tested by DEQ laboratory staff on a weekly, monthly, or quarterly basis at 77 sites on Saipan, Rota, and Tinian (Appendix 1). These sites are used for swimming, boating, or fishing. Many of these sites were established in 1984 and have been sampled on a relatively continuous basis since then.

The parameters of salinity, temperature, and dissolved oxygen content are measured directly in the field using a refractometer and handheld YSI 56. Water samples are collected and analyzed for turbidity levels, pH, and fecal coliform content in the laboratory.

The presence of fecal coliform is currently used by the CNMI as an indicator of microbial contamination of nearshore waters. Studies (***cite***) have shown that other species may be more valuable field indicators of contamination of human origin. The DEQ laboratory is exploring the possibility of using *C. perfringens*, fRNA phage, enterotoxigenic *E. coli*, and *Shigella* sp. This marine monitoring plan will be revised as needed to reflect the results of the research.

These water quality parameters will continue to be monitored at the established sites on a regular basis as a part of this marine monitoring plan. In addition, whenever the marine monitoring team conducts a general biota or coral survey or suspended solids study at one of the eight permanent sites, these water quality parameters will be measured.

Sampling period: weekly - western Saipan beaches; monthly - Tinian harbor and beaches; quarterly - eastern Saipan beaches and Rota harbor and beaches.

B. **Nitrogen and phosphorous** (DEQ Marine Monitoring Quality Assurance Plan 1996).

Under natural conditions, the nutrients, nitrogen and phosphorous, are limiting factors in coral reef ecosystems. Corals, the base of the ecosystem, have adapted to and thrive in nutrient-poor waters. When additional nutrients are added to the water, overall productivity of the ecosystem may increase, but species diversity is likely to decrease. Often the corals will be replaced by algae.

Nutrients in the nearshore environment are often from upland sources, such as roads, golf courses, agricultural fields, groundwater seepage, and residential areas. Because the amount of nutrients in the water can have such a profound effect on the nearshore environment, it is essential that we monitor their levels and develop a baseline database.

DEQ laboratory staff will incorporate nitrogen and phosphorous sampling and analysis into the established marine water quality testing regime described in Section A. Water samples from the 77 established sites will be collected and analyzed in the laboratory for nitrogen and phosphorous levels using a Hach DR/4000 V Vis spectrophotometer on the same schedule as the other water quality parameters are analyzed. In addition, whenever the marine monitoring team conducts a general biota or coral survey or suspended solids study at one of the eight permanent sites, nitrogen and phosphorous levels will be measured.

Sampling period: weekly - western Saipan beaches; monthly - Tinian harbor and beaches; quarterly - eastern Saipan beaches and Rota harbor and beaches.

C. **Chlorophyll *a*** (Devlin and Lourey 1996)

The amount of chlorophyll *a* present in the water provides a good indication of plant, especially phytoplankton, biomass. Because plants thrive in nutrient-rich waters (poor conditions for corals), high levels of chlorophyll *a* in nearshore

waters indicate a significant amount of nutrient-rich run-off is likely entering the water.

Even though we will be directly measuring the concentration of nutrients in the water, as described in Section B, it is still important to measure the amount of chlorophyll *a*. Comparing the amount of chlorophyll *a* in the water to the amount of nitrates and phosphates will provide a direct correlation of nutrient levels to plant biomass. It can also provide an indirect correlation of the amount of run-off to coral health.

DEQ laboratory staff will incorporate chlorophyll *a* sampling and analysis into the established marine water quality testing regime described in Section A. Water samples from the 77 established sites will be collected and analyzed for chlorophyll *a* levels using a Hach DR/4000 V Vis spectrophotometer on the same schedule as nutrient and other water quality parameters are analyzed. In addition, whenever the marine monitoring team conducts a general biota or coral survey or suspended solids study at one of the eight permanent sites, chlorophyll *a* levels will be measured.

Measuring nutrient levels and phytoplankton biomass are two new studies that will require new equipment and additional training for the DEQ laboratory. The first year of the marine monitoring program will focus on becoming familiar with nutrient analysis. Phytoplankton biomass determination will be incorporated in the second or third year of the program.

Sampling period: weekly - western Saipan beaches; monthly - Tinian harbor and beaches; quarterly - eastern Saipan beaches and Rota harbor and beaches.

D. **Sedimentation** (English, et. al. 1994 and Marine Monitoring Quality Assurance Plan 1996).

Sedimentation caused by upland activities poses a major threat to the survival of corals because corals depend on clear waters. Heavy sedimentation adversely affects many aspects of coral survival, including coral growth and recruitment, which can result in fewer coral species, less live coral, lower coral growth rates, greater abundance of branching forms, and decreased net productivity (English, et. al. 1994).

Sediment traps yield time-integrated samples of material settling from the water column (English, et. al. 1994). When these traps are used in conjunction with the photo-quadrat survey (described in Part 2 Section D), they will help the marine monitoring team correlate sedimentation rates with recruitment, growth, and mortality of individual coral colonies over time.

Four sets of three sediment traps will be placed near each permanent quadrat at the eight permanent monitoring sites. The samples will be collected monthly by the marine monitoring team. The DEQ laboratory staff will dry and weigh the

samples to determine the rate of sedimentation and nature of the sediments at each location. In cases where unusually high rates of terrigenous sedimentation is occurring, the marine monitoring team will attempt to identify upland sources that may be causing the sedimentation.

Sampling period: monthly

2. GENERAL BIOTA AND CORAL SURVEYS

Surveying the general biota and coral cover over a period of time to monitor changes in species abundance and health is essential to determine if the nearshore environment is being adversely affected by upland events. Establishing a baseline database of general biota and coral cover will help researchers determine which land-use practices are harmful to the marine ecosystem and which practices have relatively little effect. The baseline information will also show which mitigation practices are most suitable for avoiding or minimizing impact. The database will also show natural variability in community structure over time.

A brief description of each general biota or coral survey is described below. A more complete description of the methodology can be found in the DEQ Marine Monitoring Quality Assurance Plan (1996), or other listed reference.

A. **Broadscale survey** (Oliver et. al. 1995, English et. al. 1994, and DEQ Marine Monitoring Quality Assurance Plan 1996).

A large-scale study of the reefs of the CNMI has never been conducted. A broadscale survey will help the marine monitoring team categorize the reefs with respect to percent coral cover and determine the effects of large-scale disturbances on the coral reef ecosystems.

The broadscale surveys will not be limited to only the eight permanent sites. All reefs of Saipan, Tinian, and Rota, and some of the Northern Islands reefs will be sampled by the marine monitoring team on a yearly basis.

Teams of observers will conduct a series of two minute tows over each reef crest. The observers will assign a category value representing percent cover for live, dead, and soft corals and will count crown of thorn starfishes and feeding scars. The data will be summarized and a value for each parameter assigned to each reef.

Sampling period: yearly

B. **Line Intercept Transcet** (Oliver et. al. 1995, English, et. al. 1994, and DEQ Marine Monitoring Quality Assurance Plan 1996).

Line Intercept Transects (LITs) are benthic surveys used to describe the sessile community of coral reefs. LITs use lifeform categories to provide a morphological description of the reef community (English, et. al. 1994).

Specifically, the LITs will provide an estimate of the total area of the reef covered by different lifeforms of the sessile benthic community. The surveys may be used to compare compositions of reefs or to assess the impact of natural and anthropogenic disturbances on the reef.

This method is effective for detecting environmental disturbances because the morphological make-up of a reef may change as the result of a natural or anthropogenic event. For example, branching corals are more prevalent in waters with higher sedimentation rates (Rogers 1990).

Each of the eight permanent sampling sites will have five transects of 20 meters length located haphazardly at each of two depths, shallow (three meters) and deep (ten meters) (80 transects total). The members of the marine monitoring team will record the lifeforms and their intercepts encountered under the tape.

Sampling period: biannual

C. **Point Quarter Method** (UOG Marine Laboratory and Quinn and Tomokane 1996).

The point quarter method was developed initially by terrestrial ecologists to describe the plant community of an area. The method has since been adapted for underwater use to describe coral communities. This is a "plotless" method that can be used to measure density, number of individuals and species, size of colonies, percent coverage, diversity, and a number of other parameters.

The point quarter method will be employed by the marine monitoring team at each of the eight permanent sites, near each group of LITs located at both three meters and ten meters depth. A point on the transect will be selected at random. From this point, the distance to the nearest coral species will be measured and recorded. The species and size will also be recorded. Twenty random points will be selected and concurrent measurements made at each sampling site.

Sampling period: biannual

D. **Permanent Quadrat Method** (English, et. al. 1994 and DEQ Marine Monitoring Quality Assurance Plan 1996)

The permanent quadrat method is designed to monitor changes in the macrobenthos community through time by providing a visual record (maps and photographs) of coral colonies located in a permanent quadrat. Sedimentation rates measured by nearby traps are correlated with growth, mortality, and recruitment of corals.

The permanent quadrat method provides an in-depth look at how certain coral colonies react to natural or anthropogenic disturbances. The maps and photographs will be a permanent visual record of each site and will allow for long-term generalizations. Growth rates, mortality rates, and recruitment can be inferred from the records.

A permanent quadrat site (2 meters x 2 meters) will be established by the marine monitoring team at each of the eight permanent sites, near each group of LITs located at three meters depth. Four sets of three sediment traps will be placed near each quadrat. The marine monitoring team will tag and measure individual colonies and draw maps of the quadrat, showing type, position, and size of the coral colonies within the quadrat. Vertical-plane photographs of the quadrat will be taken to refine the field map.

Sampling period: biannual

E. **Butterflyfish survey** (Crosby and Reese 1996)

Because many species feed exclusively on coral polyps, butterflyfish (chaetodontids) are indicators of health of coral reefs and can be used to assess ecological conditions. The fishes' abundance, distribution, and behavior are dependent on coral health.

A butterflyfish survey will be conducted at four of the five LITs at three meters depth at each sample site. The marine monitoring team will determine territory size, the number of agnostic interactions, and feeding rates for three pairs of fish along the transect.

Sampling period: biannual

F. **Coral reef fish visual census** (English, et. al. 1994)

Fish communities are a major resource of coral reefs. Fish are probably the most obvious living creature in a coral reef ecosystem, with each group of fish fulfilling an important niche. They are often the most culturally and economically important animal in the ecosystem as well.

Abundance of certain species of fish and the composition of the community is dependent upon the health and composition of the coral reef. For example, the relative abundance of certain butterflyfish (chaetodontids), coral feeders, and parrotfish (scaridae), algal grazers, will depend upon the relative abundance of coral and algae. The coral reef fish visual census will attempt to detect differences in assemblages of reef fishes at different sites using abundance categories and will estimate sizes of the fish.

Each LIT (described in Section B) will be extended to 50 meters to conduct the reef fish visual census. A core group consisting of several species will be censused. These core groups will be selected to obtain an estimate abundance of species that are favored *targets* of fishers, *indicator* species, and *visually obvious* species. The census will be conducted by an observer swimming along the transect and recording fish from this core group encountered within 2.5 meters of either side and five meters above the transect.

It will take one or more years for the marine monitoring team to develop their fish identifying skills to a level sufficient to make an accurate visual census. The team will work on improving their skills during the first two years of the program and will begin conducting actual studies during the third year of the program.

Sampling period: biannual

G. **Video monitoring** (QUEST)

A picture is worth a thousand words and a video is worth a thousand pictures. When attempting to portray certain facts to the public or convince decision-makers to take a specific action, videos are a very effective tool, especially since many of the viewers may never have been underwater before. Underwater videos can also be used to document monitoring stations, sampling efforts, and visually obvious events such as an oil spill.

The marine monitoring team will create a video that shows all eight monitoring stations. The permanent quadrats will also be video-taped, although not at the same frequency as they are photographed. Major events, such as storm damage or unusually high amounts of run-off will be recorded.

Sampling period: biannual

H. **Aerial photo survey**

When the opportunity arises, the marine monitoring team will take photographs of unusual events, such as sediment plumes, from the air.

Sampling period: as needed

3. DATA MANAGEMENT

The DEQ Marine Monitoring Quality Assurance (QA) Plan describes the data collection and management procedures of the marine monitoring program. The QA plan provides detailed descriptions of how all data should be collected, stored, and analyzed. This plan provides only a general description of how the data collected by the marine monitoring team will be managed.

Data management is an intricate part of any long term monitoring program. Collected data are useless if they cannot be analyzed and used to make sound resource management decisions. A database will be developed to store the data, designed to reflect the objectives of the marine monitoring program. An essential component of the data management section is that the data are analyzed on a regular basis. Because the primary goal of this program is to take a long term look at the health of the nearshore ecosystem, it is also essential to maintain a continuity of procedures and sites so that the data can be compared from year to year.

A. **Records**

Each agency will keep a record of who participated in each study, which survey was done, where it was conducted, and what the diving profile was (if applicable). DEQ will keep all original data sheets and provide copies to the other agencies. The original data sheets will be kept on file for five years.

B. **Databases**

The DEQ laboratory has data sheets to record water quality parameters and a database will be developed to store and regularly analyze this data. The Australian Institute of Marine Science has developed a database called ARMDES (AIMS Reef Monitoring Data Entry System), which will be used to record and analyze data collected from manta tows and LIT surveys. Additional databases will be developed to record the data collected from point quarter, permanent quadrat, and butterflyfish surveys; the coral reef fish censuses; and the underwater videos.

C. **Assignment of responsibility**

The Division of Environmental Quality will assume the role of database manager. Any agency may have access to the database to review the data and conduct analyses, but only individuals from DEQ may enter or delete data. This will insure that the integrity of the data is maintained and there is accountability for the data.

4. REPORTING

Comprehensive data analysis will be reported to the respective program directors on a quarterly basis. In addition, a public report will be developed on a quarterly and annual basis. This report will describe the studies that were conducted during the previous time period and will briefly outline the major findings from the surveys.

5. ACTION

This section should describe how we will insure the proper agency responds to the problem detected in the monitoring program. Describe what action steps to take when we find something unusual from our surveys, i.e., if we find fecal coliform at the beaches we will notify the public -- we should also work to find the source of the contamination by sampling upstream.

(F) References

American Public Health Association, American Water Works Association, and Water Pollution Control Federation (1985). Standard Methods for the Examination of Water and Wastewater. 16th edition. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Baltimore, Maryland.

ASEAN-Australia Marine Science Project: Living Coastal Resources, (1994). Survey Manual for Tropical Marine Resources. Edited by English, S., C. Wilkinson, and V. Baker. AIMS, Townsville, Australia.

Australian Institute of Marine Science, (1995). Long-term Monitoring of the Great Barrier Reef, Status Report Number 1. Edited by Oliver, J., G. De'Ath, T. Done, D. Williams, M. Furnas, and P. Moran. Townsville, Australia.

Crosby, M.P. and E.S. Reese. 1996. *Monitoring Coral Reefs with Indicator Species: Butterflyfishes as Indicators of Change on Indo-Pacific Reefs*.

Devlin, M.J. and M.J. Lourey, 1996. Water Quality- Field and Analytical Procedures. AIMS, Townsville, Australia.

Division of Environmental Quality Water Quality Quality Assurance Plan (1993).

Division of Environmental Marine Monitoring Quality Assurance Plan (1996).

Oliver, J., G. De'Ath, T. Done, D. Williams, M. Furnas, and P. Moran. Eds. 1995. *Long-Term Monitoring of the Great Barrier Reef*. Australian Institute of Marine Science. Townsville, Australia.

Pring, Cynthia K., 1989. Marine Monitoring Program, Assessment and Recommendations. Saipan, CNMI.

Quinn, N.J. and J. Tomokane, 1996. Nonpoint Source Marine Monitoring Program, First Year Progress Report 1994-95, Draft 1.14. Saipan, CNMI.

Rogers, C.S. (1990). Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series, 62: 145-152.

University of Guam, Marine Laboratory (1993). Standards for Scientific Diving Certification and Operation of Scientific Diving Program. Mangilao, Guam.

Lau Lau Bay Survey, Lau Lau Bay marine baseline survey, OTEC survey, Scuba diver survey, watershed maps