



NOAA FISHERIES

Pacific Islands Fisheries Science Center

WELCOME MESSAGE

We are pleased to welcome your participation in what we believe will be an important workshop for defining directions for marine ecosystem research in the Marianas archipelago over the forthcoming five years. This work can only be successful with your involvement not only in this workshop but also in the implementation of the research itself. This is a big job and requires a collaborative effort by all involved. I am committing our staff to fully work with you and hope you will reciprocate to the extent possible.

Finally, we appreciate the hospitality of the Commonwealth of the Northern Mariana Islands and its people.

Best of luck and Aloha,

Samuel Pooley, Director
NOAA, Pacific Islands Fisheries
Science Center

Mariana Archipelago Ecosystem Science Implementation Planning Workshop 2013

SCHEDULE

PRE-WORKSHOP EVENING PLENARY

Monday, May 20 • 6:00 - 7:00 pm • National Park Auditorium (American Memorial Park)
Opening Remarks and Welcome to the Workshop

MARIANA ARCHIPELAGO SCIENCE TALK #1

Keynote Speaker—Dawn Kotowicz, Human Dimensions Research Program, PIFSC
Topic: Results of Traditional Fishing and Monuments Management Preferences Research

DAY-1 WORKSHOP

Tuesday, May 21 • 8:00 am—5:00 pm • Azucena 2 Conference Room, Fiesta Resort

SESSION 1: Setting the Stage

SESSION 2: Transboundary Species

SESSION 3: Fisheries Resources

(see full detailed agenda attached)

DAY-2 WORKSHOP

Wednesday, May 22 • 8:00 am—5:00 pm • Azucena 2 Conference Room, Fiesta Resort

SESSION 4: Benthic Environment

SESSION 5: Latitudinal Gradients

(see full detailed agenda attached)

POST-WORKSHOP EVENING PLENARY

Thursday, May 23 • 6:00 - 7:00 pm • National Park Auditorium (American Memorial Park)
Summary of Workshop Discussions and Next Steps

MARIANA ARCHIPELAGO SCIENCE TALK #2

Keynote Speaker—Ken Kramer

Topic: First Voyage to the Marianas Trench Marine National Monument



Mariana Archipelago Ecosystem Science Implementation Planning Workshop 2013

TUESDAY, MAY 21 – WORKSHOP DAY 1 – FIESTA RESORT, AZUCENA 2

8:00 – 8:15 am	Welcome and introduction	Arnold Palacios
8:15 – 8:30 am	Overview of workshop process	Eric Breuer
8:30 – 10:30 am	SESSION 1: Setting the Stage	
8:30 – 8:45 am	Mapping the Marianas	Rob O’Conner
8:45 – 9:00 am	Human Dimensions: Current and Historical	Judy Amesbury
9:00 – 9:15 am	The Future of Fisheries	Manny Duenes
9:15 – 10:30 am	PANEL 1 Q&A	Panel Members
10:30 – 10:45 am	Break	
10:45 – 12:30 am	SESSION 2: Transboundry Species	
10:45 – 11:00 am	Highly Migratory Species	Eric Breuer
11:00 – 11:15 am	Cetaceans	Erin Oleson
11:15 – 11:30 pm	Turtles	Tammy Summers
11:30 – 12:30 am	PANEL 2 Q&A	Panel Members
12:30 – 1:30 pm	Lunch (on your own-local area)	
1:30 – 3:30 pm	SESSION 3: Fisheries Resources	
1:30 – 1:45 pm	Reef Fish	Terry Donaldson
1:45 – 2:00 pm	CNMI Commercial Bottomfish Fisheries	Trey Dunn
2:00 – 2:15 pm	Fisheries Resources around Guam	Brent Tiabbats
2:15 – 2:30 pm	Invertebrates	Mike Tenorio
2:30 – 3:30 pm	PANEL 3 Q&A	Panel Members
3:30 – 3:45 pm	Break	
3:45 – 4:30 pm	Public questions and comments	
4:30 – 5:00 pm	Summary and discussion	Eric Breuer
5:00 pm	Adjourn	



Mariana Archipelago Ecosystem Science Implementation Planning Workshop 2013

WEDNESDAY, MAY 22 – WORKSHOP DAY 2 – FIESTA RESORT, AZUCENA 2

8:00 – 8:30 am	Overview of Day 1 outcomes	Eric Breuer
8:30 – 10:30 am	SESSION 4: Benthic Environment	
8:30 – 8:45 am	Coral	Roberto Venegas
8:45 – 9:00 am	Other invertebrates	John Furey
9:00 – 10:30 am	PANEL 4 Q&A	Panel Members
10:30 – 10:45 pm	Break	
10:45 – 12:30 pm	SESSION 5: Latitudinal Gradients	
10:45 – 11:05 am	Latitudinal Gradients: Ecology, Climate, and Oceanography	Todd Miller
11:05 – 11:20 am	Experimental Program to Stimulate Competitive Research (EPSCoR) Grant	Jason Biggs
11:20 – 12:30 pm	PANEL 5 Q&A	Panel Members
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12:30 – 1:30 pm	Lunch (on your own-local area)	
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1:30 – 3:30 pm	Open Discussion	Eric Breuer
3:30 – 3:45 pm	Break	
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3:45 – 4:30 pm	Public questions and comments	
4:30 – 4:45 pm	Summary and discussion	Eric Breuer
4:45 – 5:00 pm	Next steps	Eric Breuer
5:00 pm	Adjourn	



NOAA
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PIFSC

Mariana Archipelago Ecosystem Science Implementation Planning Workshop 2013

Overview

The National Marine Fisheries Service, NOAA Fisheries is convening a 2-day workshop in Saipan, Commonwealth of the Northern Mariana Islands. The workshop, which will be held the week of May 20th 2013, will focus on formulating a five-year (2014-2019) research implementation strategy to 1) address knowledge gaps identified in the Marianas Trench Marine National Monument Ecosystem Science Plan and 2) contribute to existing baseline data on the linkages between biological, geophysical, and human components of the Mariana Archipelago Ecosystem (including the Marianas Trench Marine National Monument (MTMNM)).

Workshop Description

The workshop is being planned in consultation with a planning committee of local scientists and resource managers from the Commonwealth of the Northern Mariana Islands (CNMI) and Guam Natural Resource Agencies, University of Guam and the United States National Park Service.

The 2 day workshop will include the following activities:

- Discussion on research priorities and knowledge gaps.
- Identification of viable research strategies to address gaps and priorities.
- Identification, discussion and evaluation of ecosystem monitoring and observation activities.
- Output: Based on workshop discussions, NOAA Fisheries will develop a Mariana Archipelago marine research implementation plan for 2014-2019.

In addition to the workshop a one-day add-on meeting will be held after the workshop that will present, review and evaluate targeted research projects to be conducted onboard the NOAA Research Vessel Oscar Elton Sette which will be in Marianas' waters late spring 2014.

- Output: the expected deliverable from the add-on meeting is a list of potential research projects that PIFSC will consider for inclusion into the Oscar Sette 2014 research plans.

Public Participation

Interested members of the public are encouraged to attend the workshop. A period of time will be designated for public Q&A and input related to presentations and discussions held at the workshop.

Environment of Interest

The Mariana Archipelago provides a unique natural mesocosm for investigations into the complex connections between organisms (including humans), their physical, biotic, cultural, and economic environments, and the wide range of processes that control their dynamics. Responding to these challenges requires an ecosystem-based approach to management that accounts for the complex connections between organisms (including humans), their physical, biotic, cultural, and economic environments, and the wide range of processes that control their dynamics. Fully implementing an ecosystem-based approach to management requires ongoing scientific research. It is not yet fully understood how the marine ecosystem of the Marianas

will respond to a changing climate or the management structures being put into place, such as the implementation of no commercial fishing in the Islands Unit of MTMNM. Our understanding of the MTMNM ecosystem within the broader context of the Mariana Archipelago – including its diverse biota, links to other components of the ecosystem, and the benefits they provide to society – is limited.

Workshop Background and Scope

Presidential Proclamation 8335 established the MTMNM in 2009. The Monument is divided into three “units” (the Islands Unit, the Trench Unit, and the Volcanoes Unit), consisting of submerged lands and waters within the Mariana Archipelago.

Presidential Proclamation 8335 calls for the establishment “of a program to assess and promote monument-related scientific research and exploration.” In addition to this, NOAA Fisheries has management responsibilities for the fisheries resources, habitats, and marine mammals found throughout the waters of the Mariana Archipelago. In September 2011, NOAA Fisheries Service Pacific Island Regional Office and NOAA’s Office of Ocean Exploration and Research took the first step toward meeting the responsibilities designated in the presidential proclamation by holding a workshop to discuss scientific exploration and research within the MTMNM.

In 2012, staff from NOAA Fisheries Pacific Islands Fisheries Science Center conducted 21 meetings in the CNMI including, Saipan, Tinian and Rota, and in Guam with a range of stakeholders and partners to solicit input and ensure local participation in the development of a MTMNM Ecosystem Science Plan.

The Mariana Archipelago Marine Ecosystem Science Implementation workshop is the “next step” in research planning for the waters of the Mariana Archipelago and the MTMNM. It is the first in a planned series of workshops. The 2013 workshop will be focused on research to support NOAA Fisheries core focus: 1) maximizing the sustainability of fisheries and fishing communities; 2) recovering and conserving protected species; and 3) habitat processes.

This document describes proposed workshop topics, providing an introduction to the research needs in the NOAA Fisheries MTMNM Ecosystem Science Plan, as well as those identified by the Workshop Planning Committee and MTMNM managers. The research questions described herein are suggestions; it is expected that the workshop will expand and refine these questions through group discussion and targeted panel question and answers, as well as identify possible new topics and questions.

Add-on Activity

Following the 2-day workshop, a one day session will be held that will review and evaluate proposed research projects to be conducted using the NOAA Research Vessel Oscar Elton Sette (scheduled for a Mariana Archipelago Fisheries Insular Survey Research Trip late spring 2014). A short document will be circulated to scientists, managers and educators throughout the Marianas and Guam which will provide a summary of the ship's capability and provide guidelines for how to submit research projects for consideration. This document will be issued well before the workshop to allow potential participants the time to plan a project. Contact phone numbers and emails will be provided for those wishing to submit a project for consideration but unable to attend the workshop. Projects submitted through email or mail will also be presented and discussed. Evaluation criteria will be based on NOAA Fisheries mandates, links to the MTMNM Ecosystem Science Plan, and relationship to the marine environment of the MTMNM and overall benefit to the local community. Multidisciplinary projects that meet multiple requirements are encouraged to maximize available resources. No project is guaranteed federal support or ship time. Each project will be reviewed and evaluated by NOAA Fisheries in planning the 2014 NOAA research season.

DAY 1 • WORKSHOP THEMES

Workshop Themes

Ecosystems can be considered at a variety of scales, but are generally considered to be a complex system comprised of the living and non-living environment. Ecosystems may be defined by species life history characteristics, habitat types, geography, geology, and/or processes. The Fisheries Ecosystem Plan for the Western Pacific¹ defines the Mariana Archipelago to include all of the waters within the Exclusive Economic zone of CMNI and Guam. This ecosystem definition is useful in examining broad scale processes, such as regional oceanographic patterns and distribution of highly migratory species (which includes both fish stocks, such as tunas, marlins, sharks, swordfish, and mahi, as well as some marine mammal and sea turtle species).

However, there is a recognition that a latitudinal gradient exists within the Mariana Archipelago, and the workshop planning committee felt part of the discussion in the workshop should look at these gradients as they relate to patterns of fish and habitat distribution, among other factors. This approach was taken by the NOAA Fisheries Pacific Islands Fisheries Science Center Coral Reef Ecosystem Division (CRED) in developing their 2003-2007 report.² CRED made comparisons between the inhabited islands of Guam, Saipan, Tinian, and Rota, and the uninhabited Northern Islands.

The Planning Committee agreed to structure the workshop into 6 subsections, these are: 1) Setting the Stage (includes an overview of mapping, historical human occupation and general overview of latitudinal gradients); 2) Transboundary Species; 3) Fisheries Resources; 4) Benthic Environment; 5) Latitudinal Gradients; and 6) Open Discussion. The remainder of this document provides detail on each of these areas. Several research questions are provided to initiate discussion.

SESSION 1: Setting the Stage

Mapping

Benthic habitat mapping and characterization has been extensively done for the nearshore epipelagic environments of the MTMNM Islands Unit with several benthic habitat mapping products developed collaboratively by the NOAA Fisheries Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED) and the Biogeography Branch of the NOAA Center for Coastal Monitoring and Assessment, National Centers for Coastal Ocean Science. They demonstrated that approximately 50% of the seafloor surrounding the MTMNM Islands Unit is below 100 m depth (Farallon de Pajaros≈55%; Maug≈58%; Ascuncion≈45%).

Research Questions:

1. How do we increase our knowledge and understanding of the biological communities that inhabit the deeper environments surrounding the Islands Unit of the MTMNM?
2. How do we use developing advanced technologies to map these areas and provide insight into the unique deep sea environment of the MTMNM?

¹ Western Pacific Fisheries Management Council. 2005. Fishery Ecosystem Plan for the Mariana Archipelago. 247p.

² Brainard RE, Asher J, Blyth-Skyrme V, Coccagna EF, Dennis K, Donovan MK, Gove JM, Kenyon J, Looney EE, Miller JE, Timmers MA, Vargas-Ángel B, Vroom PS, Vetter O, Zgliczynski B, Acoba T, DesRochers A, Dunlap MJ, Franklin EC, Fisher-Pool PI, Braun CL, Richards BL, Schopmeyer SA, Schroeder RE, Toperoff A, Weijerman M, Williams I, Withall RD (2012) Coral reef ecosystem monitoring report of the Mariana Archipelago: 2003–2007. NOAA Fisheries, Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-12-01, 1019 p.

3. What is the best method for providing the data necessary to fill the gaps in bathymetric data?
4. How do we increase our understanding of the complex environments in the Mariana Archipelago that support fisheries? Has adequate mapping of these areas been completed? If not, where are the gaps?

Human occupation and exploration of the Islands Unit

Recent archaeological work at Pagan and Sarigan, islands to the south of the Islands Unit, found abundant remains dating to the Latte Period. The occupation of the islands north of Saipan may have begun late in the Prehistoric Period, but populations on some islands remained relatively high until the Spanish *reducción* in 1697-98. Archaeological work on the three northernmost islands would inform on the timing and extent of the human occupation during the Prehistoric Period. If archaeological fishbones are collected, analysis would reveal which families of fishes were exploited during that time. Ascertaining the historical fishing activity in the Islands Unit could provide a time series of the types of fish targeted that would be useful in filling knowledge gaps on historical usage patterns.

Research Questions:

1. What do the archival records tell us about the human occupation and exploration of the three islands in the Islands Unit? Historical records dating to the Spanish, German, Japanese and American Periods should be examined for references to the Islands Unit. Particularly helpful are the documents compiled and translated by Rodrigue Lévesque.
2. Describe the human experience of residents who lived in the northern islands during Japanese and American Periods? Interviews with people, who have lived in the Islands Unit, Saipan residents who lived on Asuncion during the Japanese Period, should be undertaken in order to document occupancy during the Japanese and American Periods.

SESSION 2: Transboundary Species

Marine Mammals

Humpback whales were targeted by the whaling industry in Micronesia in the late 19th and early 20th centuries. Although commonly reported by fishermen and other ocean users today, information about their migratory patterns, stock affiliation, and overall use of the archipelago are unknown. It is not known whether this population is a remnant of the harvested one or if these migrations emanated from a splinter group of another population, or some combination of both scenarios. Tagging of individuals around the southern islands of the Mariana and tracking their movement would aid in the elucidation of this population, and provide valuable insight into the ability of humpback whales to rebound from extensive harvesting. Similar information on fin, blue, sei, and other endangered whales would also be valuable, as their status in the western Pacific is not known.

A number of cetacean species are known to occur throughout the archipelago, though their population structure, seasonal movements, and habitat are not known. Cetaceans were observed in the lagoon at Maug during the 2003/05 CRED cruises. Additionally, cetaceans were observed around Asuncion Island in 2005. PIFSC surveys in the southern portion of the archipelago have identified a number of common species whose range likely extends to the northern islands, but systematic or extensive surveys have not been conducted. It is likely that cetaceans occur in designated or planned military training areas in the Marianas, including the Islands Unit. The vulnerability of these populations to Naval or other anthropogenic sounds may depend on their overall range and whether these operating areas are important habitat for each species.

The current deployment of High-Frequency Acoustic Recording Packages (HARP) off the west side of Saipan and the east side of Tinian by the PIFSC Protected Resources Division (PRD) will provide important information on cetacean movement patterns. Coupled with the annual surveys around Guam, Rota, Tinian and Saipan, cetacean research has expanded significantly in the past few years. Nevertheless, research needs to be expanded to the broader Mariana Archipelago, with the placement of HARPs at locations near Pagan, where potential military training activities are planned in the future, in order to establish a baseline of cetacean activity. Additionally, HARP placements around Maug would provide data for the MTMNM Islands Unit. Expansion of the cetacean surveys to the Northern Islands would further enhance the quality and quantity of coverage in the Mariana Archipelago.

Research Questions:

1. Which threatened and endangered cetacean species use the archipelago and what are their overall usage patterns?
2. Do productivity zones exist that can be linked to cetacean distribution?

Turtles

It has been estimated that between 1,000 and 2,000 mainly immature resident green turtles reside around southern arc islands of the CNMI, including Saipan, Tinian and Rota. Observations from isolated reef systems in the CNMI documented only three individuals of the green sea turtle, *Chelonia mydas*, one sighting of which was at Supply Reef within the Islands Unit of the MTMNM.

Sea turtles are not known to nest in the MTMNM Islands Unit due to the steep profiles and lack of fine sand beaches. The movements, however, of endangered sea turtles around the three northernmost islands is not known. Furthermore, the movement patterns around and through the Trench Unit are also unknown. It has been shown that loggerhead sea turtles follow the Transition Zone Chlorophyll Front in the central western Pacific.

Research Questions:

1. What are the seasonal habitat usage and movement patterns of the sea turtles species found in the Mariana Archipelago?

SESSION 3: Fisheries Resources

Marine Biology

Fish

Pelagic Apex Predators

The movement of large pelagic apex predators in the western Pacific is a topic that has not been well studied. Previous tagging efforts by the Secretariat of the Pacific Community (SPC), although not targeted in the Marianas, have not resulted in high returns, perhaps due to low or undocumented fishing effort. This dearth of information necessitates support of tagging research in the Mariana Archipelago that may be helpful in managing these species.

The abundance of large pelagic apex predators has become a concern in recent years due to the observed alteration of trophic levels in large basin oceanic systems. The use of various types of tags to track animals that range widely has evolved significantly, although a considerable amount of tagging studies have been accomplished regarding the movement of large pelagic apex predators, nothing is known regarding movements in and around the Mariana Archipelago.

Life History Information

With the National goal of ending overfishing and overfished stocks the initial implementation of Annual Catch Limits (ACL) proved to be a challenge, especially in data-poor regions such as the central and western Pacific. As a result there needs to be better information on fisheries resources in the Marianas, as well as the development of different approaches in utilizing limited and often highly variable data resources in producing more accurate estimates of Allowable Biological Catches (ABC) for use in ACL implementation. Improving the collection of fishery dependent resources has long been a desire of both Guam and the CNMI. Recent advances include the implementation of PIFSC-funded biosampling programs in both jurisdictions to obtain information on coral reef and deep bottom commercial fisheries landings, and support for the collection of life history data from species in those fisheries.

Research Questions:

1. What are the life history parameters for targeted fish stocks?
2. Will expanding the current life history sampling program throughout the Marianas as well as adjacent jurisdictions increase our present knowledge on age and growth estimates for species of economic importance in the Mariana, existing under differing environmental conditions and fishing regimes?

Invertebrates

Little information pertaining to invertebrate fisheries in the Mariana is available. Invertebrate surveys by local natural resource agencies and PIFSC CRED Reef Assessment and Monitoring Program (RAMP) have provided some data on *Acanthaster planci* (crown of thorns sea star). The majority of this work has been restricted to the shallower depths in the Islands Unit or in the southern islands of the Mariana Archipelago.

Research Questions:

Previous workers found that temporally proximate outbreaks of *A. planci* that occur across spatially separated populations are genetically independent and most likely due to similar extant conditions that result in plankton blooms.

1. Are *A. planci* outbreaks within the Mariana Archipelago spread through mass dispersal events or are island specific localized events?
2. What are the species distributions of potential commercial species such as sea cucumbers, giant clams, *Ranina ranina*, (Kona crab), deep shrimp (e.g. *Heterocarpus* spp.), spiny lobsters, slipper lobsters and *Trochus*?
3. What is the full catalogue of macrofaunal species (and their distribution) in the MTMNM, particularly in those regions with limited information?

DAY 2 • WORKSHOP THEMES

SESSION 4: Benthic Environment

Corals

Precious Corals

The extent of the precious coral resource in the Mariana Archipelago remains unknown. This baseline information would be useful in developing estimates of sustainable yield towards evaluating the potential of this resource to support a long-term commercial fishery.

Research Questions:

1. What is the diversity, abundance and distribution of precious coral species in the Mariana Archipelago?

Other Corals

Further work on coral species diversity and ecology is needed in the Mariana Archipelago. Past research has provided basic descriptions of coral dominated systems in the Mariana Archipelago but more work is required. Additional work is required in coral systematics in order to clarify estimates of the current knowledge of coral diversity, as the proposed listing of coral species by NOAA Fisheries PIRO has extensive ramifications regarding the ability to do research.

Acquiring a better baseline of the anthropogenic, climatic, physical, and oceanographic stress that mold coral reef development in the Marianas remains a long-term goal that is of high priority to local natural resource managers.

Research Questions:

1. What is the diversity, abundance and distribution of non-precious coral species in the Mariana Archipelago?

Algae

There is a significant need to have all existing collections of algae from the Mariana Archipelago identified and catalogued, especially those collected from the West Mariana Ridge, from which prior collections do not exist. Having these collections identified will not only improve the understanding of species diversity but will also illuminate ecological relationships in the diverse coral reef ecosystems present in the Mariana Archipelago.

A Caribbean algal species, previously identified from the Philippines and the Ryuku Islands of Japan, was spotted on Santa Rosa Reef south of Guam. The potential of similar observations in the Mariana Archipelago, in particular the West Mariana Ridge due to its relative proximity to the Philippines and the Ryuku Islands, requires further sampling effort.

Research Questions:

1. What do current collections tell us about species diversity and ecological relationships among algae in the Mariana Archipelago?

2. Do the algae at the northern islands exhibit seasonality during the cooler winter period? Both the 2003 and 2005 NOAA Fisheries cruises were conducted during the late summer of August and September, and the 2007 NOAA Fisheries cruise was conducted during the early summer of May and June.

SESSION 5: Latitudinal Gradients

Hydrography

Large scale circulation patterns have been studied and elucidated for the Mariana Archipelago and with a small extent within the MTMNM waters themselves. To better understand the ecosystem and provide the best science to managers more detailed work generating data and building models is required.

Research Questions:

1. What are the flow mechanics within the MTMNM waters around the Islands Unit and throughout the Archipelago?
2. How does the hydrography within the MTMNM influence temperature, nutrients, biogeochemical reactions, plankton production, coral reef ecology and other properties in the MTMNM ecosystem? (Note: Maug crater is very unique and the semi-enclosed crater with its limited flushing creates an overlap of chemosynthetic and photosynthetic processes that has a major impact on the ecology there).
3. What are the sediment flow and flux dynamics in the near shore environments of the Mariana Islands?

Threats

Contaminants

A recent technical report by the Water and Environmental Resources Institute (WERI) of the University of Guam, as well as recent publications, showed elevated mercury levels in reef food fish from Saipan Lagoon, as part of a collaborative project with the CNMI Division of Fish and Wildlife. This research also led to identification of a land-based mercury source. This research demonstrates the need to understand both the source and the pathway of contaminants into the marine ecosystem and the biogeochemical processes occurring within the ecosystem.

Understanding the environmental fate, biological accumulation, and adverse effects of contaminants, broadly defined to include toxic substances, pathogens, sediments, and excess nutrients is critical to managers within the Mariana Archipelago.

Research Questions:

1. Assess patterns of contamination in the MTMNM ecosystem.
2. What do we know about contaminants in Mariana Archipelago marine species, especially those targeted for consumption?

Invasive/non-native Species

Invasive species (e.g. zebra mussels in the Great Lakes, brown tree snake in Guam, etc) have caused enormous problems for fishermen, boaters, policy makers and other biota. While much is known about invasive species in Hawaii, little is known about the species in the MTMNM. Maug was historically used as a

harbor for safe sheltering from storms. Pagan was heavily used during war time the Japanese. The transshipment of goods from the lower islands to the northernmost islands, historic commercial fishing trips, military exercises on ships and visits by unregulated, unreported and illegal fishing operations all provide opportunities for transfer of non-native and invasive species into the MTMNM waters. Ships entering and exiting large commercial harbors in Guam and Saipan and the waters of the MTMNM are vectors for these non-native and invasive species.

Research Questions:

1. What are the number and distribution of marine invasive species in the Mariana Archipelago/MTMNM?
2. What are the vectors and pathways by which marine invasive species enter the Mariana Archipelago/MTMNM?
3. What factors control marine invasions, and at what spatial scale?
4. What are the ecological and economic impacts of invasive marine species?
5. What are the biological impacts of invasive marine species on native marine fauna and flora?

Ocean Acidification impacts

After an extensive review and analysis of existing literature it was determined that to accurately characterize the threat of ocean acidification (OA) to the MTMNM, improvements in baseline monitoring, surveys, process studies, and modeling are necessary. Only after research methods, strategies, and programs are adequately developed to provide the best available scientific data, will NOAA then be able to create effective policy and implement suitable management plans. The dynamic environments and protected status of the MTMNM presents an opportunity to conduct the science required to create the comprehensive research required to provide the science to MTMNM resource managers.

The MTMNM ecosystem is a key area to study due to the calcifying populations, high biodiversity, and spawning and feeding links to marine biological communities.

Research Questions:

1. How do we develop an observation program to measure and monitor changes in carbonate chemistry within the Marianas?
2. How do we develop a research project to test the hypothesis that reduced calcification rates by a variety of marine invertebrates will occur under elevated CO₂ conditions?
3. Elevated CO₂ concentrations have also been shown to have chemosensory, auditory, and neurological effects that impair behavioral activities in non-calcifying animals including predatory and antipredator behaviors of marine fishes.
 - A. Do younger fish suffer greater climate-impacts compared to larger life stages and species?
 - B. How do we set up a research project to monitor and test the effect of increased CO₂ in the marine waters of the Mariana Archipelago
4. Does a direct effect on individual species create large-scale indirect community changes? .
5. What is the baseline for monitoring OA, and how is it changing?

Erosion impacts

For the Islands Unit rock slides are common on Farallon de Pajaros and Asunsion, and can shear off early stage coral communities impacting the overall shape of the coral communities. A landslide was observed by MARAMP CRED during the 2005 survey at Asunsion. Intense rumbling was heard by the fish and benthic teams and soon after visibility was decreased from 75 to 5 feet. Thus, these events can be viewed as significant in two respects:

- The slide of rocks and rubble into the steep sloped reefs would shear or bury standing coral colonies;
- The (re)suspension of sediment into the water column would serve to stress coral colonies.

Understanding the biological impacts of these geologic activities can lead to predictions on how coral communities in the Mariana Archipelago may change over time.

Research Questions:

1. How are geologic events shaping coral communities on the volcanic northern islands? What can this tell us about the fate of coral reef communities elsewhere with similar geological features?

Social and Economic analysis of impacts of the MTMNM

The Human Dimensions and Economics Research program has begun to study some of social, cultural and economic these issues in the Mariana Archipelago and MTMNM, including a look at traditional fisheries in the Islands Unit, economic aspects of the Marianas small boat fishery, and attitudes and perceptions of MTMNM. However, there is much more that can be learned about these topics especially as the MTMNM management plan is developed.