JIMAR
Joint Institute for Marine and Atmospheric Research

JIMAR
Annual Report for Fiscal Year 2006

Thomas A. Schroeder
Director

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Introduction

The Joint Institute for Marine and Atmospheric Research (JIMAR) is a cooperative enterprise involving the National Oceanic and Atmospheric Administration (NOAA) and the University of Hawaii (UH). JIMAR research spans six themes all aligned with the NOAA strategic plan and the University's Indo-Pacific mission. The relevant themes are tsunamis and other long-period ocean waves, equatorial oceanography, climate, fisheries oceanography, tropical meteorology and coastal research. The scope of these efforts spans the US affiliated Pacific Islands as well as the broader Pacific and Indian Ocean basins. JIMAR brings together research scientists from NOAA line offices, UH, and the global community to conduct research in the broad NOAA interests. NOAA line offices collaborating in the JIMAR program include the Environmental Research Laboratories (especially Pacific Marine Environmental Lab [PMEL]; Atlantic Oceanic and Meteorological Lab [AOML]; and Earth System Research Laboratory [ESRL]), National Marine Fisheries Service (NMFS), National Weather Service (NWS), National Environmental Satellite and Data Information Service (NESDIS) and National Ocean Service (NOS). JIMAR also

Thomas Schroeder, Director

supports student development, outreach and special training programs. JIMAR intends to be the lead agent for all NOAA research in the Indo-Pacific region and maintain standards of accomplishment expected of the School of Ocean and Earth Science and Technology (SOEST) at the UH.

Our mission and vision statements are as follows:

> Mission: To conduct the research necessary to properly understand and predict changes in the Indo-Pacific environment and conserve and manage coastal and marine resources in the U.S.-affiliated Pacific Islands with a special emphasis on the Hawaiian Islands, in order to meet the Nation's economic, social and environmental needs in these regions.

> Vision: To support NOAA's operational and scientific move into the 21st century while recognizing the special character, vulnerabilities, and role of the Pacific islands in demonstrating the link between our planet's environment and the global and regional economies.

During FY 2006 JIMAR continued to grow. Much of this growth has been in tsunami research and the fisheries and coastal issues associated with the creation of the Northwestern Hawaiian Islands Marine National Monument. Although the recent NOAA decision to recompete the Cooperative Institutes has added an unfortunate uncertainty to the future, we have continued to pursue implementation of recommendations of our last Review. Our level of cooperation with Hawaii Sea Grant has expanded including JIMAR participation to two new task groups; one dedicated to Hawaii water supply issues and the other coastal hazard mitigation. We continue to support development of a UH graduate program in Coastal and Marine Resources. Additionally we have been active in planning for the regional Integrated Ocean Observing System (IOOS) and Pacific Climate and Information Services (PACIS), two new initiatives of State and Pacific Basin interest.

The Director of JIMAR is a regular member of the UH faculty and is appointed through joint decisions by leaders of the University and NOAA research. He reports to an Administrative Board composed of University and NOAA officials. As both NOAA Research and University research ventures have grown, both agencies have delegated more responsibilities to the field. The Director of NOAA Research has delegated most decision-making authority to the Director of PMEL. The UH has recently undergone a cumbersome reorganization revolving around the reestablishment of a Manoa Chancellor. The President of the University has delegated his responsibilities as Chair of the Administrative Board to the Chancellor.

The Director manages day-to-day operations through the administrative staff (fully-supported by the Cooperative Agreement and returned indirect cost funds), program managers (PFRP), and faculty PI/Directors (UH Sea Level Center [SLC]). A Council, elected among the Fellows, advises the Director on major expenditures on visiting scientists as well as selection of new and renewed Fellows. The list of current Fellows and Council members are provided below. In light of the current uncertainty over the future of JIMAR under the recompetition of the Joint Institutes, we decided to continue all existing Fellows for the next biennium and synchronize the appointment periods which had been allowed to drift with arrivals and departures of individuals and development of new themes. Owing to the long-distance nature of the NOAA/JIMAR relationship, no single meeting of all Fellows is
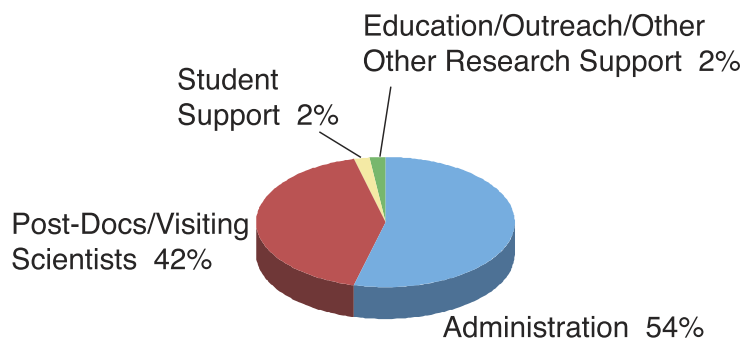
possible. Business of both the Fellows and the Council are done via e-mail and by visits of the Director to NOAA facilities and professional meetings.

JIMAR Senior Fellows from NOAA are Dr. Eddie Bernard (PMEL), Dr. Richard Brill (NMFS), Dr. Ed Harrison (PMEL), Dr. Gregory Johnson (PMEL), Dr. William Kessler (PMEL), Dr. Michael Laurs (NMFS), Dr. Frank Marks, Jr. (AOML), Dr. Michael McPhaden (PMEL), Dr. Dennis Moore (PMEL), Dr. Jeffrey Polovina (PIFSC), Dr. Samuel Pooley (PIFSC), Dr. Mark Powell (AOML), and Dr. Frank Schwing (PFEL). JIMAR Senior Fellows from the University of Hawaii are Dr. Gary Barnes, Dr. Steven Businger, Dr. Eric Firing, Dr. Charles Fletcher, III, Dr. Kim Holland, Dr. Roger Lukas, Dr. Douglas Luther, Dr. Julian McCreary, Dr. Mark Merrifield, Dr. Thomas Schroeder, Dr. John Sibert, and Dr. Bin Wang. Visiting Senior Fellows are Dr. Gerald Meehl, Dr. Jagadish Shukla, Dr. Akimasa Sumi, and Dr. Michio Yanai.

JIMAR Council Members from NOAA are Dr. Michael McPhaden, Dr. Dennis Moore, and Dr. Jeffrey Polovina. JIMAR Council Members from the University of Hawaii are Dr. Eric Firing, Dr. Julian McCreary, Dr. Thomas Schroeder, and Dr. Bin Wang.

JIMAR's Task I is the base program of JIMAR. It provides research support for the visiting scientist and post-doctoral programs, and the administrative support for the Institute. The University of Hawaii contributes to this task by bearing all the indirect cost, and by paying the salary of the director. Percentages of funding by activity are exhibited in the following chart.

Distribution of JIMAR's Task I Funding by Activity

Education/Outreach/Other Other Research Support 2%

Student Support 2%

Post-Docs/Visiting Scientists 42%
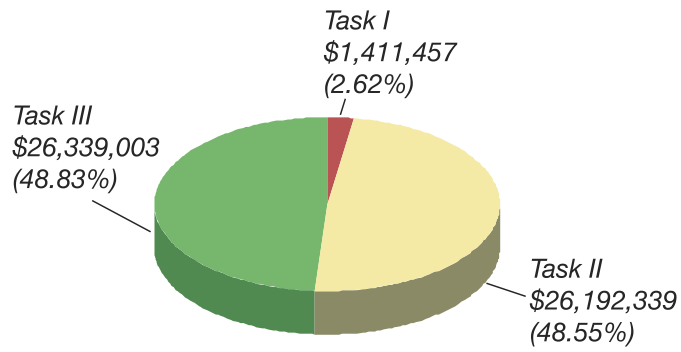
Administration 54%

JIMAR science is comprised of several dozen subprograms. In the aftermath of the Boxing Day tsunami, JIMAR has continued to play a leadership role in development of an Indian Ocean tsunami warning network. The UH Sea Level Center had developed tide gages which are capable of delivering near-real time high temporal resolution information. The Pacific Tsunami Warning Center has used our Pacific gages as part of their warning network. NOAA funds have been supplemented by grants from the Asia Disaster Preparedness Center and the United Nations.

Other JIMAR programs continued to make steady progress. The PFRP has sponsored the establishment of an array of "listening stations"—acoustic devices that detect and record the presence of fish tagged with acoustic transmitters- on all fish aggregation devices (FADs) around Oahu. Other agencies have expanded the array so that it now extends throughout the Hawaiian archipelago from Midway Island to the island of Hawaii, providing information on the movement of fisheries resources throughout the US Exclusive Economic Zone (EEZ) around the State of Hawaii.
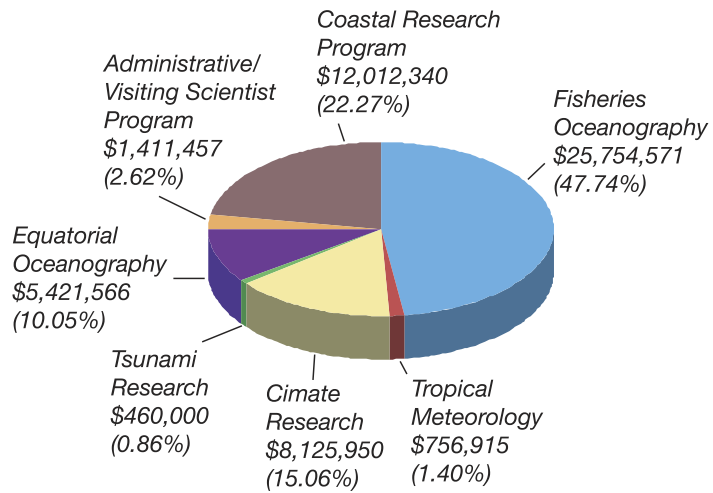
The Sustaining Healthy Coastal Ecosystems Project, a cooperative effort with the Pacific Island Fisheries Science Center's (PIFSC) Coral Reef Ecosystems Division (CRED) is featured in an article in press for *American Scientist*, to appear shortly. In this piece, they demonstrate that many thriving reefs depend more on algae than coral for their health.

Distribution of JIMAR's NOAA Funding by Task

Task I
$1,411,457
(2.62%)

Task III
$26,339,003
(48.83%)

Task II
$26,192,339
(48.55%)

Distribution of JIMAR's NOAA Funding by Theme

Coastal Research
Program
$12,012,340
(22.27%)

Administrative/
Visiting Scientist
Program
$1,411,457
(2.62%)

Fisheries
Oceanography
$25,754,571
(47.74%)

Equatorial
Oceanography
$5,421,566
(10.05%)

Tsunami
Research
$460,000
(0.86%)

Cimate
Research
$8,125,950
(15.06%)

Tropical
Meteorology
$756,915
(1.40%)

Accomplishments for Fiscal Year 2006

Equatorial Oceanography

The Joint Air-Sea Monsoon Interaction Experiment: Upper Ocean Survey (JASMINE)

P.I.: Peter Hacker, Roger Lukas, Eric Firing

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The Joint Air-Sea Monsoon Interaction Experiment: Upper Ocean Survey (JASMINE) has been a collaborative pilot study of air-sea fluxes, convection and the upper ocean response to atmospheric forcing in the tropical eastern Indian Ocean. The purpose of the field work was to obtain high-quality upper ocean, air-sea flux and atmospheric data sets focusing on the onset phase of the southwest monsoon and its subsequent evolution over the seasonal cycle. The analysis phase focused on documenting the role of intraseasonal processes.

Progress During FY 2006

In accord with project plans and funding, the research and publication of results from JASMINE has been completed. In addition, a related study on momentum balances on intraseasonal time scales in the equatorial Pacific was published (Feng et al., 2005). A final activity over the past year has been to use the JASMINE results to help plan and implement the sustained observations for the Indian Ocean via participation in the CLIVAR Indian Ocean Panel.

Penetration of Anthropogenic CO_2 in the Oceans Based on Analysis of Recent WOCE/JGOFS/OACES Carbon Data Using the Remineralization Ratios Obtained by the New Three-End-Member Mixing Model

P.I.: Yuan-Hui Li

NOAA Office (of the primary technical contact): Climate and Global Change Program

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

First, to use the three-end-member mixing model on the complete set of newly synthesized and quality assured WOCE/JGOFS and NOAA global CO_2 survey data to re-evaluate the remineralization ratios throughout the whole ocean basins. The objective of this task is to obtain new values of remineralization ratios for the global oceans and to verify that these ratios do vary systematically among ocean basins as our preliminary results have indicated (Li and Peng, 2002). Second, to develop a new method for estimating the penetration of anthropogenic CO_2 in the ocean. The objective of this task is to include the variable remineralization ratios for estimating the anthropogenic CO_2 inventory in the ocean and to provide information from an alternative method for comparison with that derived from the popular $\Delta C°$ method.

Progress During FY 2006

We find the remineralization ratios change as functions of both latitude and depth, so it is harder to apply our model to evaluate the anthropogenic CO_2 inventory in the oceans. However, we find the major cause for the change in remineralization ratios. That is due to partial conversion of organic nitrogen into N_2, N_2O, and NO by yet unidentified bacteria during oxidation of organic matter in oxycline (so-called the partial nitrification hypothesis). This finding in Indian Ocean was published in Deep-Sea Research I, 53 (2006).

University of Hawaii Sea Level Center

P.I.: Mark Merrifield

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Goal(s)

- To understand climate variability and change to enhance society's ability to plan and respond

- To serve society's needs for weather and water information

Purpose of the Project

The UHSLC, in collaboration with national and international partners, works to promote the development and operation of the global sea level network in support of climate research. The sea level network of primary concern is the Intergovernmental Oceanographic Commission (IOC) Global Sea Level Observing System (GLOSS), and especially the subset of GLOSS stations that contribute to the Global Climate Observation System (GCOS). In coordination with the IOC, USAid, and the Asia Disaster Preparedness Center, the UHSLC is involved in upgrading a subset of global tide gauge stations for tsunami warning. This has led to significant improvements of the GLOSS and GCOS networks, particularly in the Indian Ocean. The center is an end-to-end provider of sea level information, taking part in data collection, processing, distribution, scientific research, and public outreach.

Progress During FY 2006

The UHSLC collaborates with agencies in 32 countries to assist with ongoing maintenance and operation of over 50 tide gauges. During FY2006, the center established 7 new real-time reporting stations in Indonesia (Sabang, Padang, Benoa), the Philippines (Manila, Legaspi), and Thailand (Ko Taphao Noi, Ko Miang); significantly upgraded stations in the Maldives (Hanimaadho, Male, Gan), Oman (Salalah and Masirah), and Sri Lanka (Colombo); and made reconnaissance visits to Indonesia, Malaysia, and the Philippines for installations in the coming year.

A retrospective of sea level variability during 2005 and an assessment of the current state of sea level rise were contributed to the BAMS State of the Ocean report. A metric that quantifies the ability to assess global sea level rise was developed and is in the final stage of revision for OCO. A survey of 20th century sea level rise as measured by tide gauges was presented at the WCRP sea level rise workshop in Paris. Techniques for assessing land motion at tide gauges were pursued using SAR images and continuous GPS measurements.

Tsunami Research

JIMAR originated from the Joint Tsunami Research Effort and has maintained a long collaboration with PMEL in tsunami research. JIMAR scientists have been heavily involved in tsunami hazard mapping and preparedness throughout the pacific basin with special emphasis on Hawaii. JIMAR scientists have collaborated with PMEL, the Pacific Disaster Center and Hawaii State Civil Defense.

Archiving and Analysis of High-Resolution Sea Level Data from the Hawaiian Islands

P.I.: Douglas Luther

NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory

NOAA Goal(s)

- To serve society's needs for weather and water information.

Purpose of the Project

Our purpose is to acquire and archive, in an electronically accessible location, a database of high quality, rapidly-sampled ($\Delta t \leq 6$ minutes) sea level observations from existing Hawaiian shoreline gauges maintained by NOAA agencies. This sea level dataset is publicly available, via the Internet, for both practical applications and research. The archive was originally established with NOAA funding in 1997 to ensure a consistent repository for

rapidly-sampled sea level in the Hawaiian Islands for the study of weak tsunamis and related infra-gravity wave signals (including edge waves and harbor resonances) at periods of 1-10 minutes. Beyond studies of these shorter period gravity wave phenomena, the dataset will assist investigations into the dynamics of ocean phenomena such as internal and external tides (0.5 to 1 day periods), coastal trapped internal waves (1.5 to 5 days period), wind-forced mesoscale variability (3-60 days period), mesoscale eddies (60 to 180 days period), and, as the dataset length increases, interannual variability around the Hawaiian Is. Sea level data from the large majority of the gauges we access would otherwise be lost without this archiving activity; that is, the data is not saved by the agency responsible for maintaining the gauges since data archiving is not a mission of the agency. Therefore, this data rescue activity provides as complete a dataset as possible of sea level fluctuations at the coasts of the Hawaiian Is. for current and future studies of the phenomena listed above.

Progress During FY2006

The Archive of Rapidly-Sampled Hawaiian Sea Level (ARSHSL) is being maintained online (http://www.soest. hawaii.edu/oceanography/dluther/arshsl.html) by D. Luther and M. Luther, in collaboration with the NOAA-sponsored UH Sea Level Center. Data have been automatically and, if necessary, manually downloaded daily, via Internet and telephone links, from as many as 6 NOS and 15 PTWC gauges dispersed around the five main islands of Hawaii in 17 harbors (some harbors have multiple gauges). The data, as originally sampled at 1, 60, 120, or 360 second intervals, are stored on the ARSHSL web site usually after both a low-level quality control check and elimination of extreme outliers. Access to the web site is unrestricted, with users ranging from U.H. graduate students to government civil engineers, and even PTWC. The applications have ranged from hydrogeology to gravity wave studies to dock design. A technical report on the ARSHSL was prepared in January, 1998, and is periodically updated on the web site. Logs of all data holdings and processing activity are maintained on the web site for each station.

Gauge maintenance was our greatest concern this past year, since we rely on other NOAA agencies for such activity. NOS finished upgrading all its 6 Hawaiian gauges (including new communications systems) by mid-summer 2005. With the help of NOAA CO-OPS personnel we were able to re-establish archiving of 1-minute data from all these gauges (2 for the first time ever) by January, 2006. Of the 15 PTWC gauges, all but three are functioning well under PTWC's vigorous maintenance program. Only two gauges (at Hanalei, Kauai, and Laupahoehoe, Hawaii) represent significant losses, however, since the other gauge (at Kapoho, Hawaii) is redundant. Repair of these gauges is expected in the near future.

Inverse Algorithm for Tsunami Forecast

P.I.: Thomas Schroeder [Kwok Fai Cheung]

NOAA Office (of the primary technical contact): Office of Oceanic and Atmospheric Research
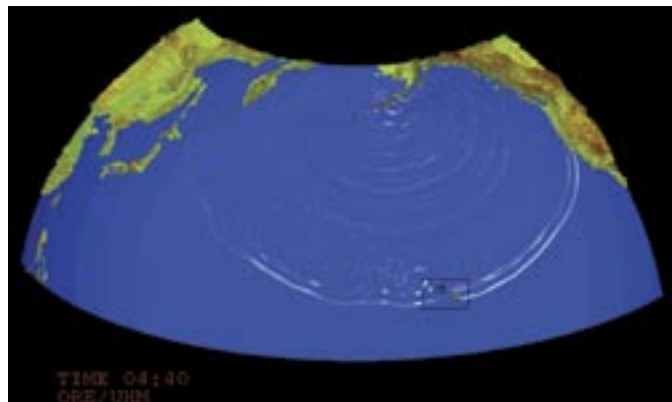
NOAA Goals

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The project develops an inverse algorithm to forecast far-field tsunamis based on near-field tsunami data. The algorithm requires a database of pre-computed mareograms. Earlier work of the PI developed and verified the mareogram database for the Alaska-Aleutian source region and the present project focuses of the Japan-Kuril-Kamchatka and Peru-Chile source regions.

Progress During FY 2006

Completed the mareogram database for the Japan-Kuril-Kamchatka source region and

Simulation of the 1946 Alaska Tsunami in the Pacific Basin.

Simulated inundation from the 1946 Alaska Tsunami at Oahu North Shore.

began work on the Peru-Chile source region. By the end of FY 2006, we will complete the forecast system for the three source regions that poses the highest risk to Hawaii.

University of Hawaii Sea Level Center—Tsunami Research

P.I.: Mark Merrifield

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Goals

- To understand climate variability and change to enhance society's ability to plan and respond

- To serve society's needs for weather and water information

Purpose of the Project

The UHSLC, in collaboration with national and international partners, works to promote the development and operation of the global sea level network in support of climate research. The sea level network of primary concern is the Intergovernmental Oceanographic Commission (IOC) Global Sea Level Observing System (GLOSS), and especially the subset of GLOSS stations that contribute to the Global Climate Observation System (GCOS). In coordination with the IOC, USAid, and the Asia Disaster Preparedness Center, the UHSLC is involved in upgrading a subset of global tide gauge stations for tsunami warning. This has led to significant improvements of the GLOSS and GCOS networks, particularly in the Indian Ocean. The center is an end-to-end provider of sea level information, taking part in data collection, processing, distribution, scientific research, and public outreach.

Progress During FY 2006

The UHSLC has been actively involved in the development of the Indian Ocean Tsunami Warning System (IOTWS) through support provided by the NOAA Office of Climate Observations, USAID, the UNESCO Intergovernmental Oceanographic Commission (IOC), and the Asian Disaster Preparedness Center (ADPC). The Indian Ocean tide gauge network has been substantially upgraded with the installation of 23 tide gauge stations by the UHSLC that are suitable for tsunami warning and monitoring. The stations provide 1 minute data every 15 minutes to regional and national tsunami warning centers via regional meteorological satellites. In addition to contributions made at the station level, the UHSLC has contributed to the design and implementation of the overall IOTWS.. For example a UHSLC Research Associate chaired the IOC/IOTWS-I Intersessional Working Group for Sea Level that determined the specifications and locations for the IOTWS CORE network of in situ sea level stations. UHSLC data from the December 2004 and the March 2005 Indian Ocean tsunamis were used in the technical design of the in situ sea level element of IOTWS, and have been used for tsunami modeling efforts. The UHSLC has also provided design specifications for the upgrade of existing Global Sea Level Observing System (GLOSS), which has resulted in these stations becoming one of the first operational components of the basin-wide IOTWS, as evidenced by the recent basin-wide advisory during the 2006 Java tsunami. UHSLC designed stations are intended for long-term sea level monitoring as well as tsunami detection, which maximizes the sustainability of these sites. The UHSLC is also training national agencies responsible for the ongoing maintenance and

operation of the IOTWS tide gauge stations. The process of developing GTS message headers and formats for sea level has been initiated with the co-chair of the Commission for Basic Systems (CBS) Expert Team on GTS and WMO Information System Operations and Implementation. Current recommendations include creating new sequences for use in reporting tide data. Individual IOTWS centers can then receive these GTS message from their respective national meteorological centers (NMCs). A GTS sea level display package has been developed with PTWC. The reliance on GTS provides a common data source for all regional and national warning centers. Plans are underway to reduce the data latency at stations located near tsunami generation sites from 15 to 1 minute using INMARSAT. The development of these services is an essential part of the effort that enables the nations affected by the December 2004 tsunami to normalize the lives of their citizens.

Climate Research

Compilation, Digitization, and Use of Hawaii State Rainfall Records

P.I.: Pao-Shin Chu

NOAA Office (of the primary technical contact): National Environmental Satellite, Data, and Information Service/National Climate Data Center

NOAA Goal(s)

- To serve society's needs for weather and water information

Purpose of the Project

To compile and digitize historical, monthly rainfall records from the Hawaii State Climate Office (HSCO) in the Department of Meteorology, University of Hawaii. The state data come from numerous volunteer observers such as sugar plantations, pineapple companies, individuals, and others. Metedata describing changes in the way the observations are taken from the handwritten records are documented. All digitized data will be entered onto the spreadsheets and be provided to National Climate Data Center.

Progress During FY 2006

We have compiled the state rain gages with more than 10 years of records for six major Hawaiian Islands (Kauai, Oahu, Maui, Lanai, Molokai, Hawaii). In all, 429 gages are compiled and digitized. Also included are the state key number, name, observer name, latitude, longitude, and elevation for each gage. Out of these 429 gages, there are 103 gages with more than 50 years of records, offering an opportunity for studying long-term climate change and variability in the tropical Pacific. In addition, we have updated historical rainfall station information for Kauai County, the current and historic station location map, and rainfall contour maps. The GIS software was used for spatial interpolation and contour plotting.

Development of Real-Time Percipitable Water Capability Using the Global Positioning System

P.I.: Steven Businger

NOAA Office (of the primary technical contact): Environmental Research Laboratory/Forecast Systems Laboratory

NOAA Goal(s)

- To serve society's needs for weather and water information

Purpose of the Project

The project objective is to maximize earth-based GPS resources. It has two primary tasks; the first is to develop, operate and maintain the SkyNet network of GPS meteorology stations in Hawaii, upgrading equipment and processing approach as necessary. The second strand is to undertake research that can be applied to maximize the utility of GPS derived integrated precipitable water vapor data to the operational meteorological and climatological community.

Progress During FY 2006

Two sites from the new Mauna Loa GPS network have been equipped with meteorology sensors and incorporated into the SkyNet network. They are now providing half-hourly estimates of integrated precipitable water vapor from locations high on the slopes of Mauna Loa that are available for ingest into weather models. The GPS site at Lihue National Weather Service Office has been relocated to the grounds of the new NWS building and provided data covering the record rainfall during February and March 2006. An agreement is being formulated with the NWS to allow broadband internet access to the new GPS site (LIHU) so that it can provide hourly data files and be fully incorporated into SkyNet.

A paper exploring the long-term statistics of water vapor has been accepted for publication in the Journal of Geophysical Research—Atmospheres. In the paper we show that water vapor is distributed approximately as a lognormal function in many locations but, that the lognormal form is "reversed" in some equatorial oceanic regions. The implications of this observation are not yet clear, but the recognition of the lognormal character may have application as a useful way of parameterizing water vapor in climate models.

Mauna Loa Project GPS site PIIK is equipped with a pressure and temperature sensor so it can be incorporated into the SkyNet GPS meteorology network.
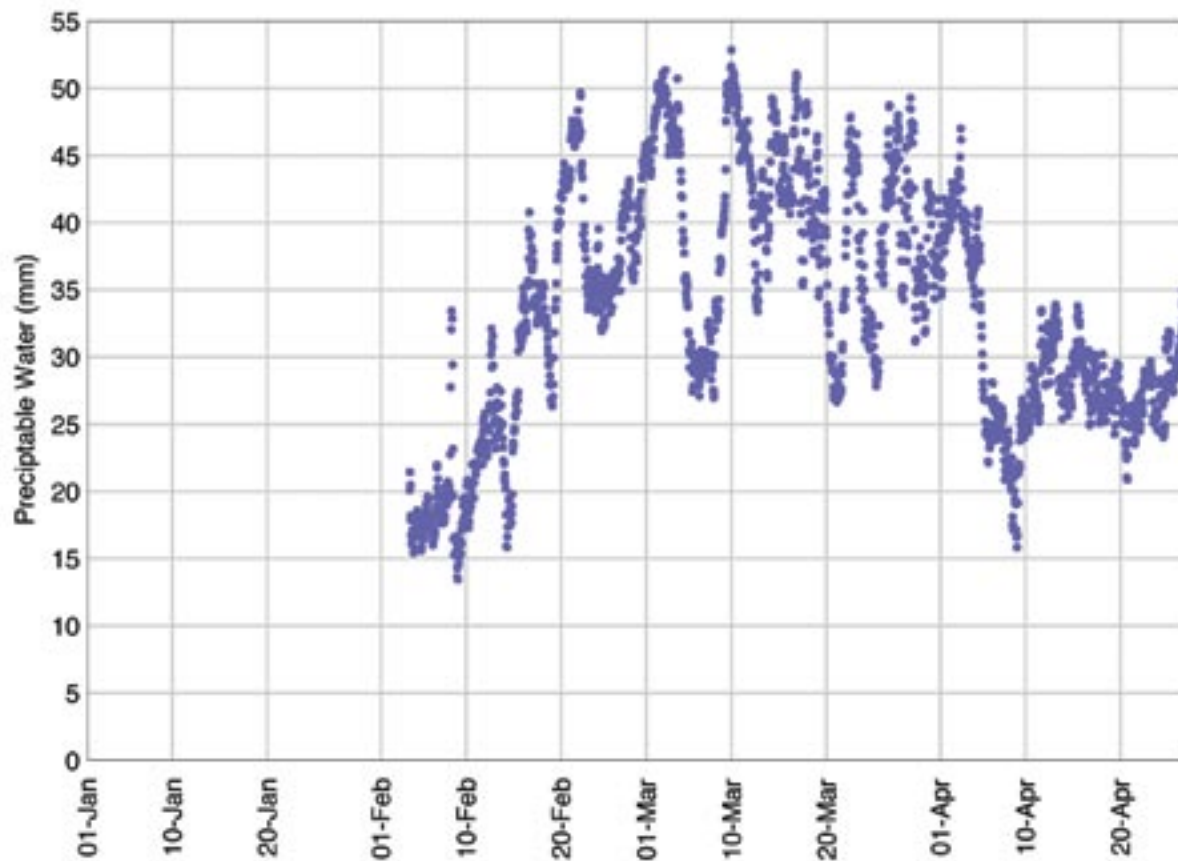
New SkyNet site LIHU in Lihue, Kauai tracks IPWV during the record rainfall of Spring 2006.

Effects of the Andes on Eastern Pacific Climate

P.I.: Shang-Ping Xie and Yuqing Wang

NOAA Office (of the primary technical contact): Office of Oceanic and Atmospheric Research

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The eastern equatorial Pacific is home to El Nino and Southern Oscillation, but the mean state and the seasonal cycle of its climate are still poorly simulated in state-of-the-art climate models. The goal of this study is to better understand and simulate eastern Pacific climate in general and the effect of the steep Andes in particular.

Progress During FY 2006

A regional ocean-atmosphere coupled model (ROAM) was developed and tested in the eastern tropical Pacific. The model succeeded in keeping the intertropical convergence zone (ITCZ) north of the equator, overcoming a long-standing bias of full-physics coupled models. The ROAM is used to study the effects of low cloud in the Southeast Pacific on the mean state and seasonal cycle of eastern Pacific. In particular, we found that the model climate is highly sensitive to the treatment of shallow cumulus convection. The PI also participated in authoring a review paper on ocean's role in three tropical oceans.

Enhancement of Data and Research Activities for Climate Studies at the International Pacific Research Center

P.I.: Julian McCreary, Jr., Peter Hacker, James Potemra

NOAA Office (of the primary technical contact): National Environmental Satellite, Data, and Information Service/National Climate Data Center

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The project enhances the operation of and the activities at the Asia-Pacific Data-Research Center (APDRC) within the International Pacific Research Center (IPRC) at the University of Hawaii. The project's overarching goals are, in part, to implement infrastructure in support of the Global Ocean Data Assimilation Experiment (GODAE) and to enhance activities in support of the Pacific Region Integrated Data Enterprise (PRIDE) in order to advance NOAA's mission objectives and meet critical regional needs for ocean, climate and ecosystem information for applications users. The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community, and the general public. The mission of the APDRC is to increase understanding of climate

The PRIDE web page.

1997   1998   1999

2000   2001   2002

2003   2004   2005
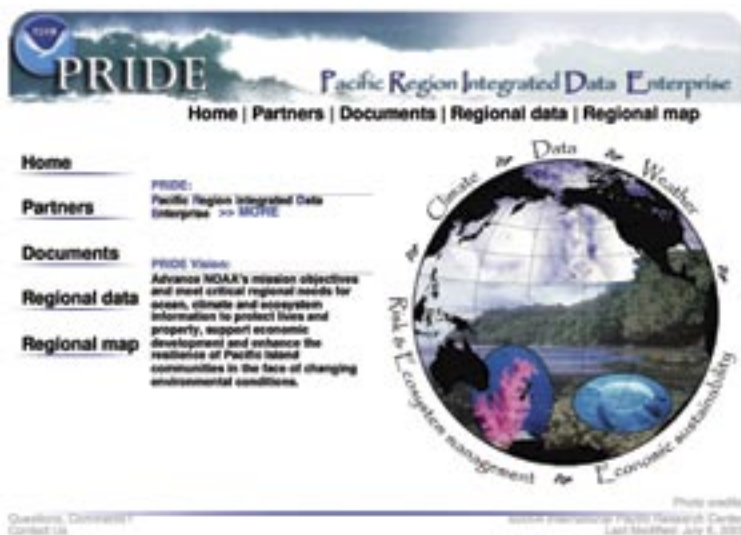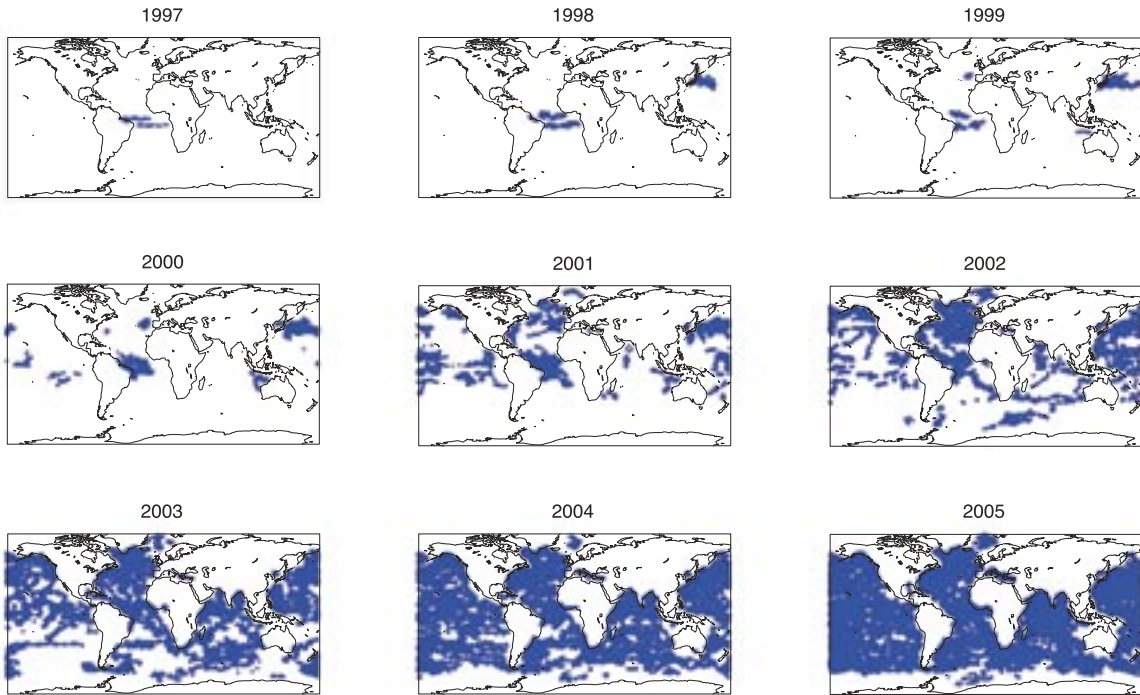
Annual distribution of Argo velocity estimates in the YoMaHa '05 dataset.
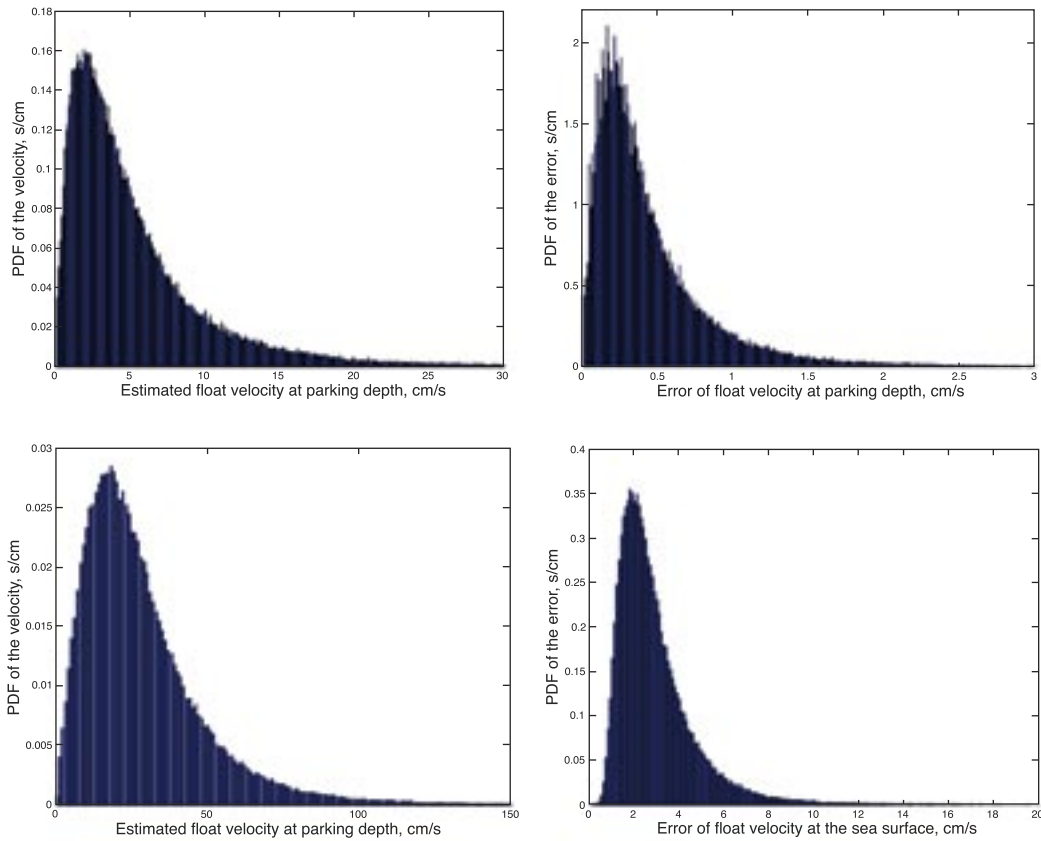
YoMaHa'05 results.

variability in the Asia-Pacific region: by developing the computational, data management, and networking infrastructure necessary to make data resources readily accessible and usable by researchers; and by undertaking data-intensive research activities that will both advance knowledge and lead to improvements in data preparation and data products.

Progress During FY 2006

We have continued to operate and upgrade our Data Server System (DSS) in collaboration with our national and international partners, and continue to build our data archive with focus on atmospheric, oceanic, air-sea flux, and model and satellite-derived products. In addition, the web-based data management tools continue to be upgraded to allow easy access to metadata, product information, and product search capability. A significant value-added activity and resulting product was the completion of YoMaHa'05 (Yoshinari et al., 2006), a global, Argo-based, surface and deep velocity product. We continue to expand our activities in support of applications and research users by providing easy access to the operational and delayed-mode ocean products prepared in the context of GODAE. A major accomplishment has been the continuous serving of the global Navy Research Laboratory (NRL) Layered Ocean Model (NLOM) products (both near-real-time and forecasts). Two years ago we began the implementation of a high-resolution model for downscaling operational models in the Hawaiian Islands region. The model has been tested with various spatial resolutions, atmospheric forcing fields and boundary conditions. Progress has been slowed somewhat because of the impact of Hurricane Katrina on the efforts of our Mississippi collaborators, who have the primary responsibility to implement the next generation Pacific Ocean operational model. We also participated in several Atmospheric Brown Cloud meetings to help that community develop their data management strategy.

In addition, four new thrusts were initiated: enhancement of PRIDE activities to develop integrated data products for the Pacific region; initiation of pilot observations in support of assimilation-based, regional high-resolution ocean models; enhancement of data rescue and historic data quality control activities; and assistance with regional coordination in support of GCOS (Global Climate Observing System) and GOOS (Global Ocean Observing System) programs. We are nearing completion of the first group of PRIDE activities for product development; results are available at the APDRC web site: http://apdrc.soest.hawaii.edu under the "Projects" heading. Pilot observations in support of high-resolution models have recently been initiated as part of the new SOEST Seaglider acquisition and field testing. We have begun to take on the responsibility for the continuing quality control of Pacific Ocean XBT data in collaboration with NODC. Finally, we are assisting with regional coordination in support of GCOS and GOOS by working with regional partners on regional data server implementation and web-based software for regional data access, display and analysis.

Impacts of Warm Pool and Extratropical Processes on ENSO

P.I.: Bin Wang

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

This project addresses how the mid-latitude atmospheric variability influences the tropical Pacific and what roles the Indo-Pacific warm pool processes play in generating ENSO irregularity and biennial variability. In general, how ENSO interact with warm pool and extratropical processes.

Progress During FY 2006

The paper of Bin Wang and An, S.-I, (2005) entitled "A method detecting season-dependent mode of climate variability: S-EOF analysis" was published. Anomalous climate is often regulated by the annual cycle. Based on this physical consideration, we propose a new method termed as Season-reliant Empirical Orthogonal Function (S-EOF) analysis to detect major modes of climate variability. The S-EOF analysis of Indo-Pacific Sea Surface Temperature (SST) variability during the past 54 years reveals two statistically significant leading modes, which are not obtainable by using conventional EOF analysis. The two leading modes represent the Indo-Pacific Low-

Frequency (LF) and Quasi-Biennial (QB) modes associated El Nino-Southern Oscillation (ENSO), and reveal the fundamental differences between the LF and QB modes in their seasonal evolution, fractional variance structure, and interdecadal variation and trend. The interdecadal variability is coupled with the LF mode, suggesting that decadal-interdecadal SST variation is primarily represented by the ENSO-like interdecadal regime shift occurred in the late 1970s. A persistent warming trend is mingled with the QB mode, accounting for a large portion of the local SST variability in the Maritime Continent-western Pacific horseshoe region.

Investigating the Transport and Transformation Mechanisms of Atmospheric Mercury in the Remote Central North Pacific Marine Free Troposphere

P.I.: Thomas Schroeder [Darryl Kuniyuki]

NOAA Office (of the primary technical contact):
Environmental System Research Laboratory/
Mauna Loa Observatory

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

Primary Task

Collection of Atmospheric Mercury Speciation Data. Provide for the collection and analysis of semi-continuous high altitude (11,400 feet) measurements of Hg0, RGM, and HgP at MLO, Hawaii. The objectives of this task will be to accumulate a long-term record of ambient Hg0, RGM, and HgP chemistry to (i) support atmospheric mercury chemistry research, (ii) establish a baseline mercury measurement station, and (iii) investigate the long range transport of mercury from South East Asia across the Pacific. In addition to this primary task, other data is measured and collected which may affect the transport and transformation mechanisms of atmospheric mercury. This includes aerosol particulate measurements, collection and analysis, gas and

Aidan Colton with the new ambient ion monitor (AIM).

particulate phase halide sample collection and analysis, semi-continuous gas and particulate phase halide collection and analysis, semi-continuous ozone, sulfur dioxide, elemental carbon, and meteorology measurements. All of the data are to be organized and archived in a database. Some data and theories will be place on the MLO web site and other types of media for outreach purposes.

Progress During FY 2006

The week of December 1st, installation of the "Ambient Ion Monitor" (AIM) was done at the observatory site. This instrument provides the semi-continuous gas and particulate phase halide collection and analysis portion listed above. Also during this time a site was chosen and a platform built for the precipitation collector, which will be arriving during the next fiscal year. All other project's data were

MLO's new chemistry laboratory.

collected and maintained as scheduled. With the increase workload we hired another JIMAR position bringing the total to four. MLO also moved to a new support facility in Hilo. A new chemistry lab was set up providing a much more functional workspace for this project.

Profiling CTD Float Array Implementation and Ocean Climate Research

**P.I.: Thomas Schroeder [Gregory Johnson]**

NOAA Office (of the primary technical contact): Pacific Marine Environmental Laboratory

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

JIMAR works with U.S. and International Argo Project partners, especially NOAA/Pacific Marine Environmental Laboratory, on three aspects of the Argo Program. The first component involves float testing, deployment, and data/engineering evaluation. The second component involves delayed-mode quality control of U.S. Argo float salinity data and international Argo data management. The third component involves climate research using data from Argo floats.
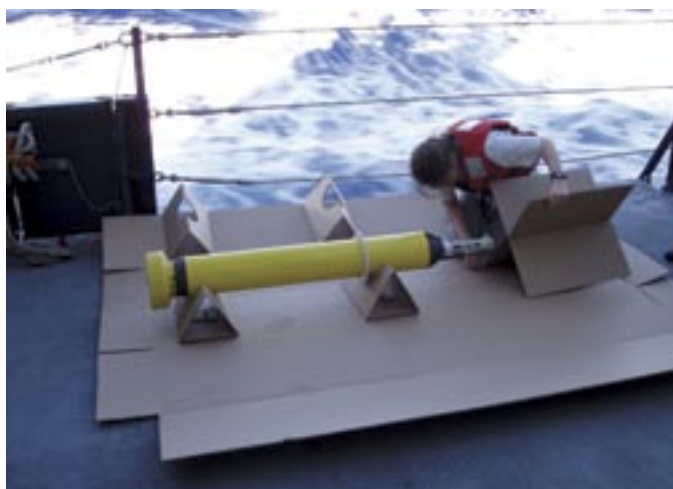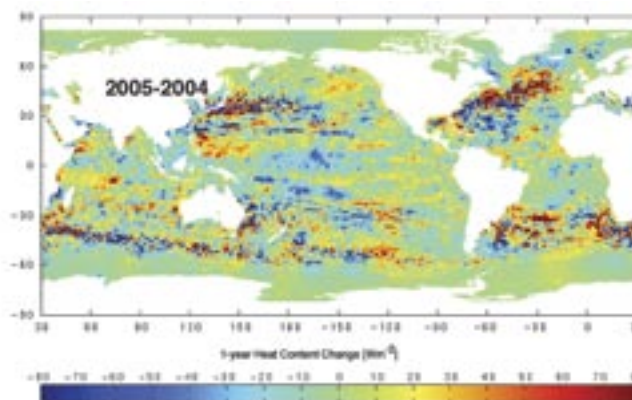

JIMAR Float Research Analyst E. Steffen preparing an Argo float for deployment in the Pacific Ocean from the R/V Melville at 12-knot cruising speed (photo by Dr. John Collins, WHOI).

Progress During FY 2006

• E. Steffen tested 86 floats, augmented all with Lithium batteries, identified 16 floats with serious problems, and helped to fix them prior to deployment. She also monitored float performance, kept up with float registrations, and helped to find and sort out float database issues. She worked on logistics for 13 float deployment cruises on 7 ships and went on two deployment cruises during which she deployed 28 floats. Stated goals were met.

• A. Wong performed salinity drift evaluation for Argo PI Dr. Steve Riser's floats, worked with Argo PI Dr. Breck Owens on improving Argo delayed-mode quality control software, and worked with Dr. Bo Qiu to prepare and submit a manuscript on S. Indian Ocean variability, and gave a presentation at an international scientific meeting. She continued to work on international Argo data management issues.

• J. Lyman produced and analyzed yearly maps

Difference of 2005 and 2004 upper (0-750 m) ocean heat content anomalies (W m-2) estimated from all available (mostly Argo) in situ ocean temperature data and satellite altimetry maps.

of global upper ocean heat content from 1993 through 2005 using in situ thermal data. Using satellite altimetry data he worked with JIMAR Senior Fellow Dr. Gregory Johnson to quantify global upper ocean heat content error estimates from 1955 through 2005. One paper on this work has been published, he has submitted another, now in revision, to a scientific journal, and he presented results at a national scientific meeting. He is presently analyzing global freshwater content variability in the upper ocean. Stated goals were met.

Roles of Ocean-Atmosphere-Land Interaction in Shaping Tropical Atlantic Variability

P.I.: Shang-Ping Xie

NOAA Office (of the primary technical contact): Office of Oceanic and Atmospheric Research

NOAA Goal(s)

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

Tropical Atlantic variability affects the climate on the surrounding continents, but its mechanisms remain unclear. The purpose of this project is to better understand the interaction of the ocean, atmosphere and land and its role in tropical Atlantic variability.

Progress During FY 2006

The Atlantic Niño, an equatorial zonal mode akin to the Pacific El Niño/Southern Oscillation (ENSO), is phase-locked to boreal summer when the equatorial easterly winds intensify and the thermocline shoals in the Gulf of Guinea. Using a suite of satellite and in-situ observations, we found a new mode of tropical Atlantic variability that displays many characters of the zonal mode but peaks in November-December (ND), statistically independent from the Atlantic Niño in the preceding summer and the Pacific ENSO. The origin of this ND zonal mode lies in an overlooked aspect of the seasonal cycle in the equatorial Atlantic.

The PI is part of the team that reviewed the research on the role of ocean in tropical climate variability in a CLIVAR special issue in Journal of Climate (Chang et al. 2006). Among other things, this review identifies the poor simulations by state-of-the-art coupled general circulation models of the equatorial cold tongue and its interannual variability as important issues to be addressed in future research.

Transition from Experimental Climate Prediction to Operational Climate Forecasting and Information Services for the U.S. Affiliated Pacific Islands (USAPI)

P.I.: Thomas Schroeder

NOAA Office (of the primary technical contact): National Weather Service, Pacific Region

NOAA Goal(s)

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The Pacific ENSO Applications Center (PEAC) was established in 1994 as a cooperative effort among the University of Hawaii (JIMAR), University of Guam, National Weather Service Pacific Region and the Pacific Basin Development Council. Subsequently the East-West Center has become a major partner in PEAC. PEAC provides climate services to Hawaii and the U.S.-Affiliated Pacific Islands. In recent years PEAC has been slowly evolving into an operational branch of the NWS Pacific Region.

Progress During FY 2006

Sea-Level Forecast

In continuation of the previous year's work, this year's (2005-2006) activities were primarily focused on enhancing the sea-level prediction capability. Because of strong demand for seasonal sea level products in the U.S-affiliated Pacific Islands (USAPI), more skillful sea-level forecasts were generated. PEAC, at present, develops a prediction of seasonal sea level in the USAPI using the teleconnections with tropical SSTs. Based on an operational Canonical Correlation Analysis (CCA) statistical model, this scheme can predict in real-time sea-level by quantifying the skill at lead times of several months or longer. The cross-validated CCA model can produce forecasts for all three-target seasons at 1- and 2-season lead times, with an average correlation skill 0.50 or more. During 2005-06, significant efforts were made to disseminate these forecasts to the user community and presently the PEAC has made significant successful efforts in publishing the real time forecast of sea level

deviations through the official web site of PEAC (http://lumahai.soest.hawaii.edu/Enso/peu/update.html). This information has also been distributed through the printed issue of Pacific ENSO Update newsletter.

Background Information on Regional Climate Dynamics
Statistical studies on regional climatology and the ENSO cycle were conducted at PEAC during 2005-06. More background information was produced to study ENSO-related impact on the Islands. Such efforts would include dissection of extreme events to examine factors affecting elevated water levels.

Generalized Extreme Value (GEV) Analysis
The NOAA CO-OPS has also recently used GEV distributions to calculate excedance thresholds for extreme storm events at 117 U.S. coastal water level stations, including those located in the Pacific. Historical monthly highest and lowest water level data were adjusted for sea level trends, so that GEV distributions could be fit to the data to determine excedance levels for various average return periods of interest. Similar analyses were initiated in 2005-06 to produce GEV for the tide gauge stations that PEAC produces sea-level forecasts.

Warm Pool Dynamics in the Interaction Between Asian Summer Monsoon and ENSO

P.I.: H. Annamalai

NOAA Office (of the primary technical contact): Climate Program Office

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The goals of the proposed research are to understand the interactive nature between the Asian Summer Monsoon (ASM) and ENSO and to assess the contributions of the warm-pool dynamics to this interaction. Our approach is through data analysis and a suite of atmospheric and ocean model experiments. The project is based on the following hypothesis: During its evolution, the ASM-related convection moves north/northwestward from the equatorial Indo-Pacific regions whereas the ENSO-related convection/heat source moves eastward along the equator in the Pacific. In effect, during the boreal summer of El Niño years, the single major heat source (monsoon in the warm pool) is partitioned into two separate pieces (monsoon and El Niño). These two heat sources subsequently interact leading to changes in the thermally direct circulations which in turn modulate the convection and SST in the warm pool leading to local air-sea interaction. These changes in regional air-sea interaction can directly interact with the ASM and subsequently affect the ENSO evolution.

Progress During FY 2006

We finished writing up / published all the manuscripts. Salient results were presented at major international conferences. The PI visited INCOIS, Hyderabad, India during June–July 2006 and presented three seminars summarizing the results obtained in the project. A brief highlight of the manuscript that investigated the monsoon and its relationship with ENSO in the IPCC coupled models is provided below.

South Asian Summer Monsoon and its Relationship with ENSO in the IPCC-AR4 Simulations
(J. Climate, in press)
In this paper we use the extensive integrations produced for the IPCC Fourth Assessment Report (AR4) to examine the relationship between ENSO and the monsoon at interannual and decadal timescales. We begin with an analysis of the monsoon simulation in the 20th century integrations. Six of the 18 models were found to have a reasonably realistic representation of monsoon precipitation climatology. For each of these six models SST and anomalous precipitation evolution along the equatorial Pacific during El Niño events display considerable differences when compared to observations. Out of these six models only four (GFDL_CM_2.0, GFDL_CM_2.1, MRI, and MPI_ECHAM5) exhibit a robust ENSO-monsoon contemporaneous teleconnection, including the known inverse relationship between ENSO and rainfall variations over India. Lagged correlations between the all-India rainfall (AIR) index and Nino3.4 SST reveal that three models represent the timing of the teleconnection, including the spring predictability barrier which is manifested as the transition from positive to negative correlations prior to the monsoon onset. Furthermore, only one of these three models (GFDL_CM_2.1) captures the observed phase lag with the strongest anticorrelation of SST peaking 2-3 months after the summer

monsoon, which is partially attributable to the intensity of simulated El Niño itself. We find that the models that best capture the ENSO-monsoon teleconnection are those that correctly simulate the timing and location of SST and diabatic heating anomalies in the equatorial Pacific, and the associated changes to the equatorial Walker Circulation during El Niño events. The strength of the AIR-Nino3.4 SST correlation in the model runs waxes and wanes to some degree on decadal timescales. The overall magnitude and timescale for this decadal modulation in most of the models is similar to that seen in observations. However, there is little consistency in the phase among the realizations, suggesting a lack of predictability of the decadal modulation of the monsoon-ENSO relationship.

The analysis was repeated for each of the four models using results from integrations in which the atmospheric CO_2 concentration was raised to twice pre-industrial values. From these "best" models in the double CO_2 simulations there are increases in both the mean monsoon rainfall over the Indian sub-continent (by 5-25%) and in its interannual variability (5-10%). We find for each model that the ENSO-monsoon correlation in the global warming runs is very similar to that in the 20th century runs, suggesting that the ENSO-monsoon connection will not weaken as global climate warms. This result, though plausible, needs to be taken with some caution because of the diversity in the simulation of ENSO variability in the coupled models we have analyzed. The implication of the present results for monsoon prediction are discussed.

Tropical Meteorology

The JIMAR tropical meteorology theme developed in response to the move of the National Weather Service (NWS) Honolulu Forecast Office to the UH Campus. The move was associated with the modernization of the NWS and was motivated in part by the long history of interaction between the Honolulu Forecast Office and the UH Department of Meteorology. Interactions among faculty, students, and NWS staff have been excellent. NWS supports student research through the NWS Education Fund (supported by in-lieu-of-rent monies) and the NWS Pacific Region Fellowship Program. Interactions with the Pacific Region extend to climate service (see ENSO Applications discussion under the climate theme) and establishment of the Pacific Training Desk.

National Weather Service Fellows

P.I.: Thomas Schroeder

NOAA Office (of the primary technical contact): National Weather Service, Pacific Region

NOAA Goals

• To serve society's needs for weather and water information.

Purpose of the Project

In lieu of rent funds support graduate students in tropical meteorology within the UH Department of Meteorology.

Progress During FY 2006

Matthew Sitkowski is near completion of his MS program. He has been working with JIMAR Senior Fellow Gary Barnes in analyzing the rapid intensification of Hurricane Guillermo (1997). Guillermo rapidly intensified over the eastern Pacific and was sampled over two days by NOAA aircraft. Data from 70 dropwindsondes have been quality controlled, treated with a cubic spline, and processed through a MATLAB program to create low-level thermodynamic and kinematic fields. Additionally, nearly one thousand radar images were collected to be used in the analysis. Latent heat release (LHR) was calculated over a 60 km radius from the circulation center to determine the relationship between intensity change and LHR trends. Several similarities and differences , some unexpected, are noted between days. Despite the rapid intensity increase between days, Guillermo's structure remains rather resilient. Aircraft data from 700 hPa reveal remarkable similarities in temperature, dewpoint, wind speed and vertical velocity for each day. The reflectivity field exhibits a wave number one pattern on each day with highest values favoring the eastern portion of the storm and asymmetries appear in both the tangential and radial wind fields. A difference of 15 ms-1 in total wind speed between the northeast and southwest quadrants of eyewall is present on both days.

National Weather Service International Pacific Training Desk

P.I.: Thomas Schroeder

NOAA Office (of the primary technical contact): National Weather Service Pacific Region

NOAA Goal(s)

• To understand climate variability and change to enhance society's ability to plan and respond

• To serve society's needs for weather and water information

Purpose of the Project

The Pacific International Training Desk provides training in modern operational meteorology to interns selected from the Weather Services of nations within World Meteorological Organization Regional Association 5. The interns are hosted at the Honolulu Weather Forecast Office. They attend various functions at the University of Hawaii Department of Meteorology as well as are introduced to climate services provided by the JIMAR Pacific ENSO Applications Center.

Progress During FY 2006

In the past year the Pacific Desk has served seven visiting interns from Niue, Samoa, Malaysia, Tonga, Vietnam, Papua New Guinea and Vanuatu.

Fisheries Oceanography

Fisheries oceanography has become the largest component of JIMAR. The program has three components: collaborative research with the Pacific Islands Fisheries Science Center of the National Marine Fisheries Service (NMFS); collaborative research with the Pacific Environmental Group in Monterey, CA: and the Pelagic Fisheries Research Program (PFRP), managed by JIMAR in cooperation with the NMFS Southwest Fisheries Laboratory, La Jolla, CA and the Western Pacific Regional Fishery Management Council.

A General Model for Protected Species

P.I.: John Sibert [Mark Maunder]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/
Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The objective of the project is to generate a general Bayesian integrated modeling framework for protected species modeling that can be applied to multiple species and used to provide management advice. Models will be developed based on the general framework and used to estimate the effect of fisheries on the protected species populations.

Progress During FY 2006

The research in the second year and third year of the project was delayed due to staffing changes. During these years the main collaborator, Simon Hoyle, reduced his time spent on the project. Therefore, the contract was extended.

Simon Hoyle developed the preliminary AD model builder code for an integrated analysis of black-footed albatross population dynamics. The final effort data required for the model were obtained in December 2005. Mark-recapture analysis results and capture histories, after the difficult processes of data preparation and model selection to achieve 'goodness-of-fit', were provided by Sophie Veran in October 2005. We were not able to apply MULTIFAN-CL to this population as the required modifications to the software are yet to be implemented. Hoyle met with Kim Rivera, National Seabird Coordinator for the US National Marine Fisheries Service, in May

2006 and discussed black-footed albatross data availability. Hoyle attended a symposium for the Pacific-Atlantic sea turtle assessment (PASTA) project in La Jolla, August 2005. He participated in discussions on methods for assessing sea turtle stocks, and presented an outline of the integrated analysis approach and its potential for use in sea turtle assessment. Hoyle is a collaborator on the PASTA project. Mark Maunder acquired additional funding from the New Zealand Ministry of Fisheries for the project "Assessment to risk of yellow-eyed penguins Megadyptes antipodes from fisheries incidental mortality in New Zealand fisheries and definition of information requirements for managing fisheries related risk" with NIWA and applied the general fisheries model CASAL to yellow-eyed penguins.

Maunder investigated the use of general fisheries stock assessment models for modeling protected species and presented a summary at the Workshop on Stock Assessment Methods, La Jolla. He visited Panagiotis T. Besbeas at the University of Kent and worked on methods to integrate data into models. Maunder attended the AFS Conference and taught a course based on the general framework and give a presentation in the Bayesian section of the conference. He also taught a course in AD Model Builder at the University of Kent. Maunder attended the objective Bayes conference in Missouri and gave a poster describing aspects of the general framework. Maunder was also an invited discussant at the Workshop on Uncertainty in Ecological Analysis run by the Mathematical Biosciences Institute, Ohio State University. He attended a workshop at the Centre for Ecological and Evolutionary Synthesis, University of Oslo, on the project "Integrated statistical analysis based on likelihood and confidence: applications to the hare-lynx population cycles and the status and structure of bowhead whales." Maunder visited New Zealand and worked with Alistair Dunn on this project. Hoyle attended the tuna conference and PI meeting. Maunder attended the PFRP Research Priorities Workshop and PI meeting in Hawaii.

Addition of Multi-Species Capability, Sex Structure and Other Enhancements to the Length-Based, Age Structured Modeling Software MULTIFAN-CL

P.I.: John Sibert [John Hampton and Pierre Kleiber]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/ Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

MULTIFAN-CL (Fournier et al. 1998[1]) is a spatially-explicit, length-based, age-structured model, which uses time-series of catch, effort, length-frequency and tagging data to obtain estimates of various population parameters, including: recruitment and biomass time-series, natural mortality rates, selectivity and catchability coefficients for defined fisheries, growth parameters and movement rates. The software is now routinely used for tuna stock assessments reported each year to the Standing Committee on Tuna and Billfish (SCTB). Several applications to Pacific pelagic fisheries have been reported in the scientific literature (Hampton and Fournier 2001[2]; Kleiber et al. 2003[3]; www.multifan-cl.org). In collaboration with agencies involved with the scientific work of the Western and Central Pacific Fisheries Commission (WCPFC), this PFRP project provides support for further development of MULTIFAN-CL to enhance its assessments of tuna stocks in the western and central Pacific Ocean and elsewhere, and to extend its applicability to species having biological characteristics and data support different than tunas. The proposed software enhancements are:

- Incorporation of enhanced parallel processing capability
- Incorporation of a modified size-frequency likelihood function
- Addition of alternative parameterizations of fishery selectivity
- Formalization of a population projection procedure
- Addition of sex structure
- Addition of multi-species capability
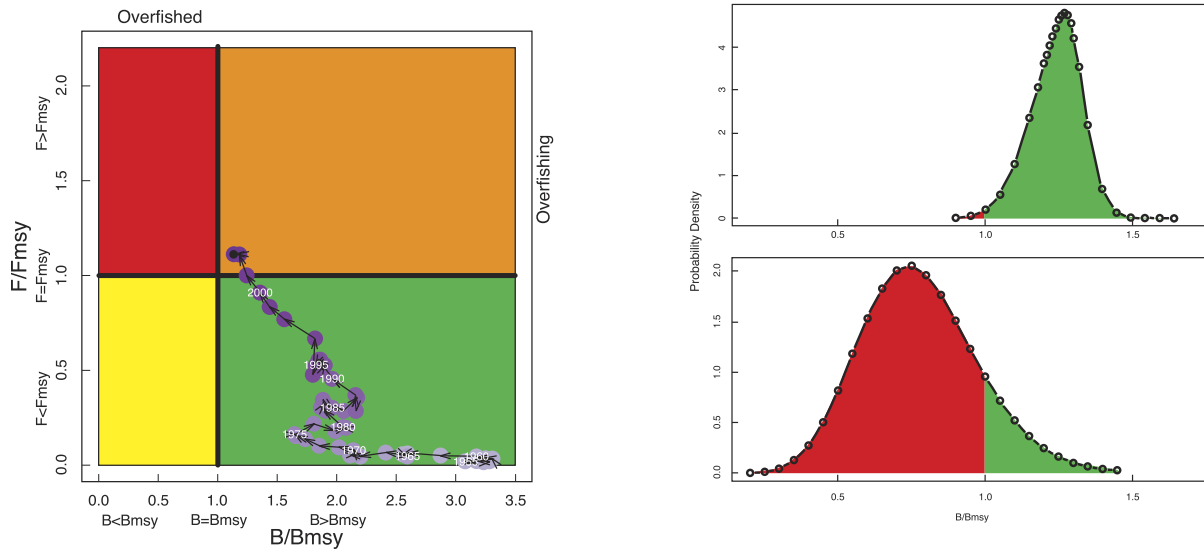
(left) Temporal trend in annual stock status, relative to B_{MSY} (x-axis) and F_{MSY} (y-axis) reference points, for the model period (1952–2005). The color of the points is graduated from mauve (1952) to dark purple (2005) and the points are labeled at 5-year intervals. (right) Profile likelihood for $B_{final}/ \tilde{B}MSY_{final}$, i.e., the biomass ratio for the final year (5) of the projection (lower panel). The $B_{current} / \tilde{B}_{MSY}$ profile likelihood based on 2001–2004 average F-at-age is shown on the same scale in the upper panel for comparison. The probability that $B_{current} / \tilde{B}_{MSY} < 1$ is approximately 0.8%; the probability that $B_{final} / \tilde{B}_{MSYfinal} < 1$ is approximately 86.5%.

Progress During FY 2006

During FY 2006 work envisaged under this project on the first four items above was essentially completed. The first objective, parallel processing, is being incorporated to improve the efficiency of the software to fill the demand for more intense computation as complicating factors are added, such as the last two items above. Some parts of the model can now function as parallel processes, and more possibilities for parallelizing remain. Items 2 and 3 implement alternative formulations of the model and have been undertaken with a view also to improved computational efficiency as well as stability of the fitting process. The use of a cubic-spline formulation of fishery selectivity in particular has proved useful and is now used routinely in stock assessment analyses. The fourth item has been undertaken in answer to demands from the WCPFC, which wishes to consider various management measures for dealing with evident overfishing in recent years of bigeye and yellowfin tuna. Population abundance and catches by various fleets can now be projected into the future under various hypothetical management regimes so that the efficacy and possible side-effects can be evaluated. It is also possible to characterize the uncertainty in projected biomass and B/BMSY using a profile likelihood technique (see above right). These feature strongly in the yellowfin and bigeye tuna assessments for the 2nd meeting of the WCPFC Scientific Committee.[4]

Regarding items 5 and 6, it has not proved feasible to complete this work within the resources provided for this project due to the unforeseen complexity of the software development required for these and several other items.

Footnotes

[1] Fournier, D.A., Hampton, J., and Sibert, J.R. 1998. MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. Can. J. Fish. Aquat. Sci. 55: 2105-2116.

[2] Hampton, J., and Fournier, D. 2001. A spatially-disaggregated, length-based, age-structured population model of yellowfin tuna (*Thunnus albacares*) in the western and central Pacific Ocean. Mar. Freshw. Res. 52: 937-963.

[3] Kleiber, P., Hinton, M., and Uozumi, Y. 2003. Stock assessment of blue marlin (*Makaira nigricans*) in the Pacific using MULTIFAN-CL. Mar. Freshw. Res. 54: 349-360.

[4] Hampton, J, A. Langley, and P. Kleiber. 2006a. Stock assessment of yellowfin tuna in the western and central Pacific Ocean, including an analysis of management options. SA WP-1, SC2, Manila, Philippines. http://www.wcpfc.org.

Hampton, J, A. Langley, and P. Kleiber. 2006b. Stock assessment of bigeye tuna in the western and central Pacific Ocean, including an analysis of management options. SA WP-2, SC2, Manila, Philippines. http://www.wcpfc.org.

Aggregation Behavior of Small FAD-Associated Yellowfin Tuna and Size-Dependent Vertical Stratification

P.I.: Kim Holland

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

To determine the FAD-associated aggregation behavior of very small yellowfin tuna and to determine if aggregated small tuna are vertically stratified by size when they are found in aggregations of mixed sizes

Progress During FY 2006

Approximately 46 FAD-associated small yellowfin tuna were captured and equipped with electronic (acoustic) transmitters and all 13 FADs around the

Very small tuna released with depth-sensitive transmitter tag

island of Oahu were equipped with Vemco VR2 acoustic receivers. Of the 46 tuna, 13 fish < 40 cm FL and 20 fish >60 cm FL were tagged with pressure sensitive transmitters that could measure the depth of these animals when they were in the vicinity of any of the instrumented FADs. These data have been analyzed on a preliminary basis and the data indicate that size-dependent vertical stratification does indeed occur.

An Analysis of Archaeological and Historical Data on Fisheries for Pelagic Species in Guam and the Northern Mariana Islands

P.I.: John Sibert [Judith Amesbury, Rosalind Hunter-Anderson]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Estanislao Taisacan, a fisherman on Rota, with two paddling canoes (galaide in Chamorro), which he and his son carved from Hernandia logs. The larger of these two canoes is about 14 feet long.

Estanislao Taisacan Jr. with the lagua' hachuman, the net used for catching hachuman (Decapterus sp. or opelu in Hawai'i). The monofilament net has a PVC rim.

Purpose of the Project

MARS is producing a report on the long-term data concerning fisheries for pelagic species in Guam and the Northern Mariana Islands. The report is based mainly on archival review. However we are also conducting interviews with fishermen on each of the four major islands (Guam, Saipan, Tinian, and Rota). In addition, we have had two collections of archaeological fish bones from Guam analyzed by Foss Leach of New Zealand to add to the data from the Prehistoric Period. We have also sent a Japanese-speaking researcher, Wakako Higuchi of Guam, to Japan to obtain fishery data from the Japanese Period in the Northern Marianas.

Progress During FY 2006

We interviewed three fishermen on Rota, which bring to 13 the number of fishermen interviewed in the Northern Marianas. We have obtained two reports from Foss Leach on the fishbone analyses of two archaeological projects on Guam, the Mangilao Golf Course Project and the Ylig Road Widening Project. We have also obtained a report from Wakako Higuchi on the Japanese fisheries in the Northern Marianas.

An Assessment of Small Boat Yellowfin and Bigeye Tuna Operations and Regulatory Scenarios in the Main Hawaiian Islands

### P.I.: John Sibert [Edward Glazier]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The primary goal of this project is to provide PFRP and the WPRFMC with valid and reliable information regarding historic and contemporary trends in commercial pursuit of yellowfin and bigeye tuna by the small boat fleet operating around the Main Hawaiian Islands. Especial focus is being applied to: (a) description and spatial analysis of private FAD fishing offshore the Big Island (b) description and explanation of changes in extent and manner of use of various gear, and (c) description and explanation of trends in market and distribution of BET and yellowfin by small boat operators. The secondary purpose of the project is to characterize the economic, social, and cultural contexts within which the BET/yellowfin small boat fisheries are conducted in the MHI. Satisfaction of these project goals will enable development of regulatory scenarios and their potential effects on the fleets and their participants. The project is the human dimensions component of the ongoing PFRP project titled "Trophic
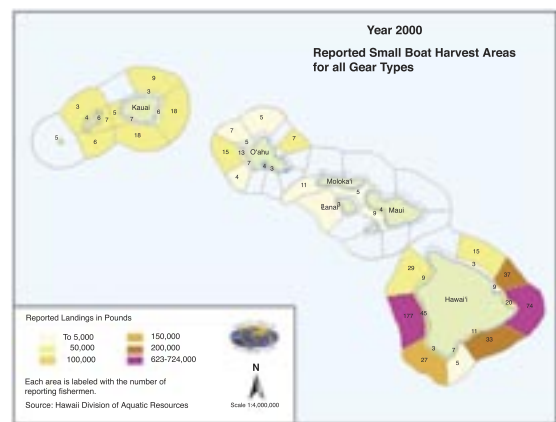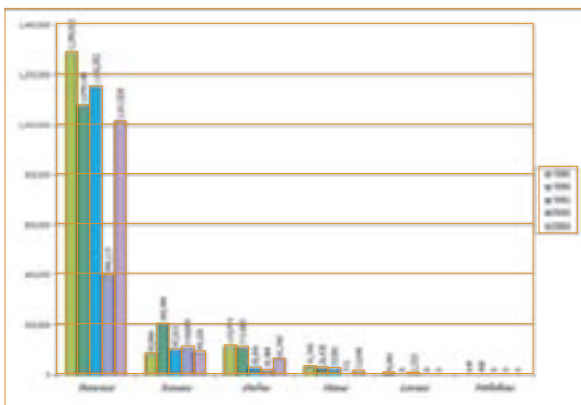
(left) Overall small-boat reported commercial landings by island, select years. (right) Reported small boat participation and landings in the MHI, year 2000.

Ecology and Structured-Associated Aggregation Behavior in Bigeye and Yellowfin Tuna in Hawaiian Waters" currently being conducted by Holland et al.

Progress During FY 2006

We remain on schedule with our FY 2006 objectives for this project. Thorough review of HDAR, NOAA Fisheries and other sources regarding trends in production and value, costs and revenue, and other critical aspects of handline, FAD, p-FAD, and other gear, strategies, and issues relevant to BET/yellowfin small boat fisheries in the MHI has been conducted. We have also conducted a long series of interviews with state and federal resource managers, scientists, harbormasters, group leaders, market personnel, and highly knowledgeable fishermen in order to more fully understand and characterize the basic operational, geographic, regulatory, and socio-political context of PFAD fishing in the EEZ of the MHI. Preliminary findings have been compiled and submitted to the WPRFMC in a background document titled "Hawai'i's Pelagic Handline Fisheries: History, Trends, and Current Status" (84 pp.).

Climate Change and Ecosystem Variability in the North Pacific Ocean and the Dynamics of Marine Resource Populations

P.I.: Thomas Schroeder [Franklin Schwing]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Southwest Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The project's purpose is to describe the characteristic modes of variability in the North Pacific Ocean over interannual to decadal time scales, from analysis of historical data bases and numerical ocean model output, and to conduct research related to the application of in situ and satellite remote sensing data products for marine fisheries and other ocean users requirements, based on a mechanistic understanding of the links between physical forcing and ecological response. These research efforts are being undertaken to: 1) improve understanding of marine environmental variability and its impacts on living marine resources, 2) develop improved living marine resource assessment models, and 3) apply satellite remote sensing technology to improve the management of economically important marine resources. This will aid in our understanding of environmental variability in time and space, and improve our ability to manage economically important and protected marine resources.

Progress During FY 2006

Biological hot spots in the ocean have distinct oceanographic signatures and are likely created by physical processes. Marine predators, including large pelagic fish, marine mammals, seabirds, and fishing vessels, recognize that prey organisms congregate at ocean fronts, eddies, and other physical features. Research in FY06 has used remote sensing observations from multiple satellite platforms to characterize oceanographic processes in four regions of the North Pacific Ocean that are recognized as biological hot spots (central North Pacific, northeastern tropical Pacific, California Current System, and Galapagos Islands). We identified dynamic features in terms of spatial scale, degree of persistence or recurrence, forcing mechanism, and biological impact (Palacios and Bograd, 2005; Palacios et al., 2006a; Yen et al., 2006). For each feature, we developed a quantitative index of its variability over the period of the satellite record. This research demonstrates that satellite oceanographic monitoring, combined with data from large-scale electronic tagging experiments, can be used to study critical pelagic habitat. The identification and monitoring of biological hot spots could constitute an effective approach to marine conservation and resource management. Continued research seeks a better understanding of which ocean features constitute hot spots, which analysis tools are most useful for their identification and description, and how to classify hot spots by ecological function (foraging, migration, reproduction, etc.) and level of biodiversity.

Research in support of the US GLOBEC Northeast Pacific Program and related activities has focused on understanding how local processes in the California Current and Gulf of Alaska ecosystems modulate large-scale
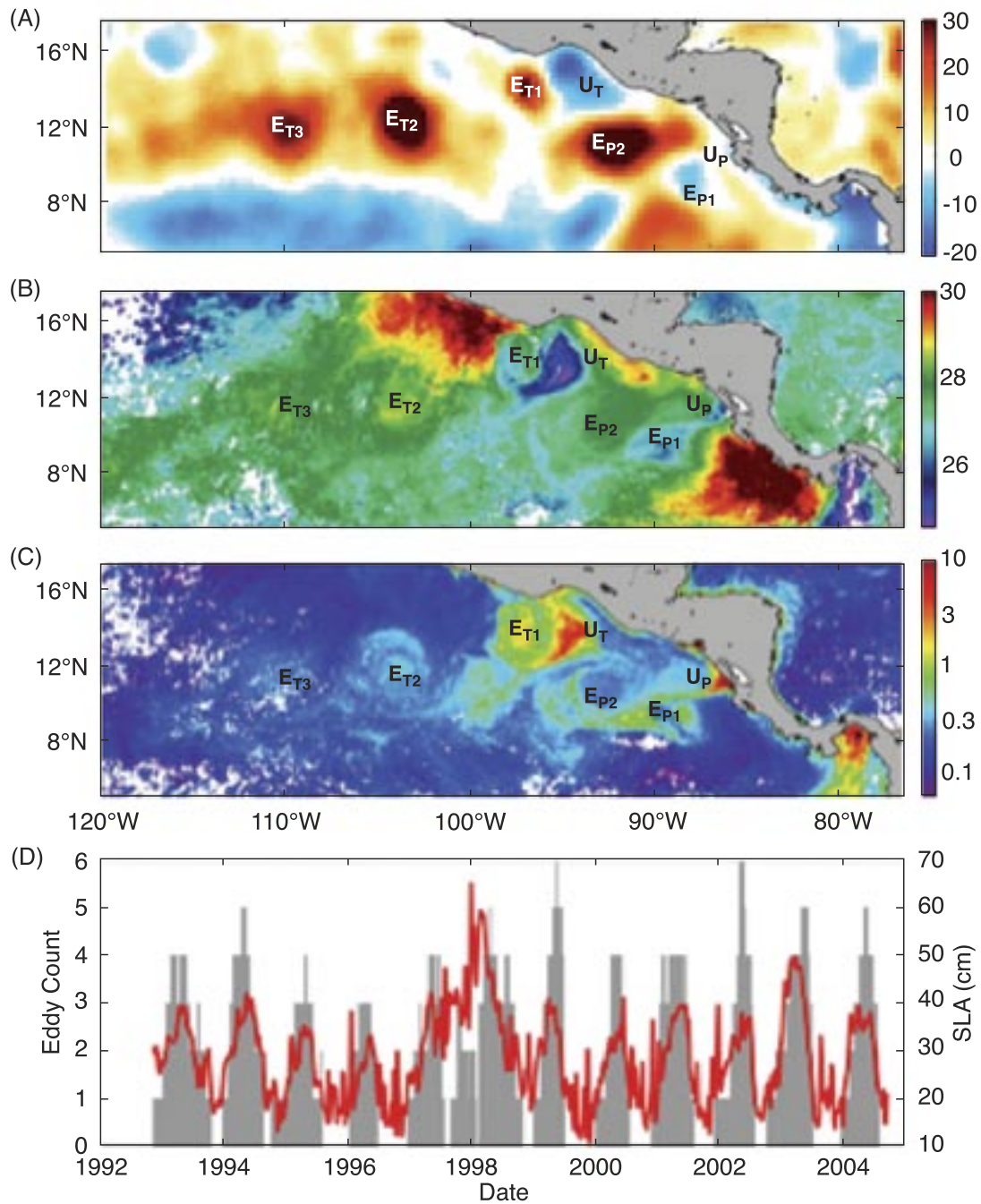
Case study for the northern eastern tropical Pacific region. (A) Sea level anomaly (SLA) (cm) for the 7-day period 30 January-5 February 2003, (B) sea surface temperature (°C), and (C) chlorophyll concentration (mg m-3) for the 8-day period 2-9 February 2003. (D) Frequency histogram of number (gray) and peak intensity (red) of all eddies observed in the region between October 1992 and August 2004. SLA range in (A) is restricted for display purposes; values as high as +48 cm occur at the center of the anticyclonic eddies. Upwelling (U) and eddy (E) features associated with the Gulfs of Tehuantepec (T) and Papagayo (P) are labeled. From Palacios et al. (2006a).

mode 1—"Global SST"   *mode 2—"Global warming"*
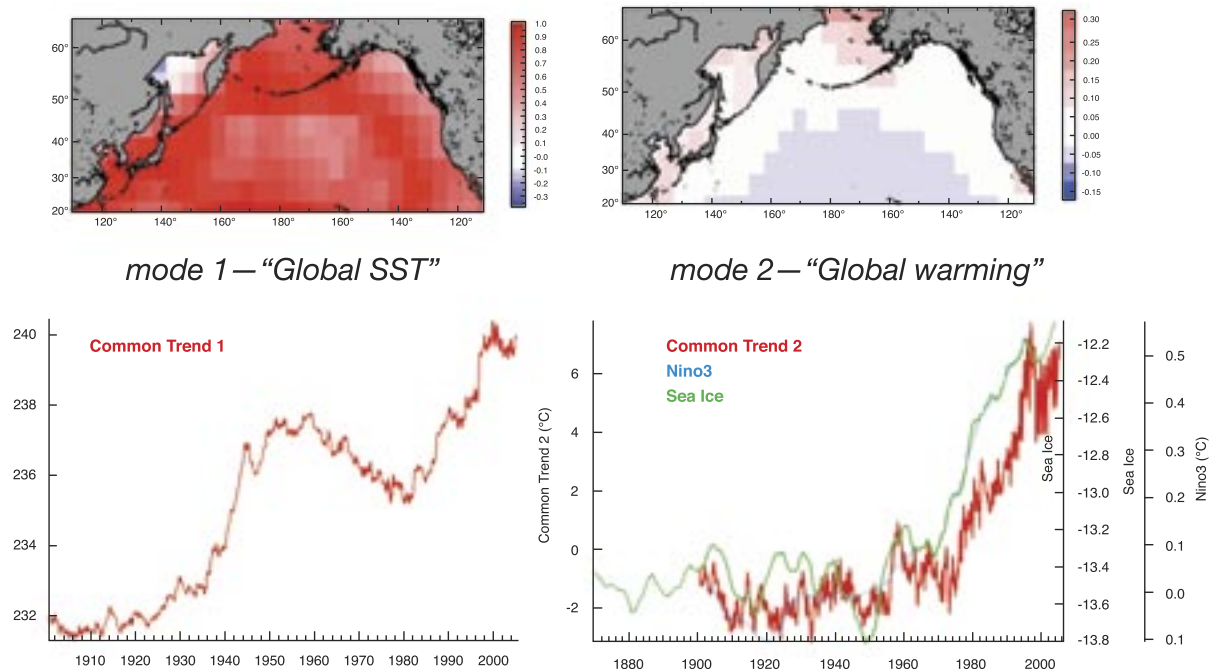
Leading modes from a common factor analysis of North Pacific SST trend time series (1900-2005). Common trend 1 (left panels) reflects basin-wide warming trend, with multi-decadal fluctuations, and reduced warming rates along US west coast, Gulf of Alaska, and Sea of Okhotsk. Common trend 2 (right panels) shows accelerated warming in subarctic Pacific in latter half of 20th Century. This accelerated warming pattern corresponds with the increased loss of arctic sea ice (green curve) and greater warming in tropical Pacific (blue curve).

climate forcing to produce a heterogeneous mesoscale response. Two approaches have been used: (1) analyzing long-term time series of oceanographic variables to describe spatial (sub-ecosystem to basin and global) and temporal (intraseasonal to interannual) patterns of variability (Bograd et al., 2005; Mendelssohn et al., 2005; Palacios et al., 2006b); and (2) developing indicators of climate and environmental variability applicable to the management of living marine resources. The time series analyses have focused on differentiating climate signals associated with long-term trends, changes in seasonality, and rapid climate shifts, all of which have significant ecosystem consequences, as well as their associated spatial patterns. Indices have been developed that account for the role of ocean stratification in determining the biological utility of upwelled waters (Palacios et al., 2006b) and that characterize ocean habitat based on water mass types (Stegmann et al., 2006).

Comparing Sea Turtle Distributions and Fisheries Interactions in the Atlantic and Pacific

P.I.: John Sibert [Selina Heppell, Molly Lutcavage]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

We are conducting quantitative and qualitative analyses of existing data on the ecology, distribution and fishery interactions of leatherback and loggerhead sea turtles in the North Pacific and North Atlantic oceans. Our primary goal is to use a comparative approach to determine why populations of sea turtles in the Atlantic appear to be stable or increasing, while populations of the same species in the Pacific are declining, even though fisheries interactions occur in each ocean basin. Because of great concerns for turtle survival, and their protected status

under the Endangered Species Act, sea turtle take in pelagic fisheries has resulted in complete closures (e.g., Hawaii, Grand Banks) or major restrictions on effort and area for the US fleet (e.g., NE Distant Sector, Atlantic). Scientific understanding of the extent and nature of world-wide take patterns in pelagic and inshore fisheries, and impacts on stock rebuilding, is incomplete, at best. Our PASTA research project is now comprised of an interdisciplinary group of sea turtle biologists, fisheries scientists, demographers, and oceanographers from federal and international agencies and academia.

Progress During FY 2006

The PASTA (Pacific-Atlantic Sea Turtle Assessment) team met for 2.5 days in La Jolla, CA in August 2005. Our first meeting resulted in a plan for analysis that includes a spatially explicit hazard assessment through GIS mapping of coastal and pelagic fisheries, relative risk assessment based on individual-based movement models, and life history assessment through age-structured modeling. Stressors that will be qualitatively assessed both spatially and temporally include mortality from fisheries bycatch, egg harvest, adult harvest, beach development, and climate change that affects the amount and distribution of forage in pelagic habitats. Our group is also working on new modeling tools that may allow for improved monitoring and status assessment. Our primary goals are to identify viable hypotheses for observed population change and to determine what primary data gaps are hindering assessment.

Describing the Vertical Habitat of Bigeye and Albacore Tunas and Post Release Survival for Marlins in the Central Pacific Longline Fisheries with Pop-up Archival Transmitting Tags

P.I.: John Sibert [Jeffrey Polovina, Michael Seki]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

To describe the vertical habitat and horizontal movements of bigeye and albacore tunas in the central Pacific. These tunas are target species in longline fisheries in both Hawaii and American Samoa, and an understanding of the habitats and movements of these species is needed as a background to fisheries management.

Progress During FY 2006

Two tagging cruises were conducted. In March 2005, around Hawaii, 16 fish were tagged with PAT tags including 9 bigeye and 1 albacore, and in February 2006, around American Samoa, 7 albacore and 2 bigeye were tagged with PAT tags. Two manuscripts were written incorporating the tagging data from previous years. Talks were presented at various scientific meetings on vertical habitats of albacore and bigeye tunas.

The NOAA Vessel O.E. Sette (background) and fishing vessel Adelita conducting oceanographic surveys and electronic tagging of albacore in American Samoa waters, February 2006.

The American Samoa tagging found that albacore primarily occupied a depth range of 150-200 m corresponding to the temperature range 20-25° C. A local maxima in microneckton biomass as estimated from acoustic backscatter was also observed at the 150-200 m depth range. The bigeye tuna tagging around Hawaii found during the day they generally occupied the depth range 250-500 m, corresponding to a temperature range of 10-14° C, while at night they were in the top 50 m.

One difficulty encountered has been a lack of marlins encountered on our tagging cruises so we have not collected the data to estimate their post release survival.

Economic Fieldwork on Pelagic Fisheries in Hawaii

P.I.: John Sibert [Minling Pan]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The primary objective of this multi-year project is to provide detailed economic information especially cost of operation data on Hawaii-based domestic pelagic fishing vessels such as longliners, trollers and handliners, and charter boats. Cost-earnings report(s) (published as JIMAR/SOEST reports) on each of these fisheries has been prepared since the project began in 1994. As a result, the data from these studies have been used in a variety of economic and social analyses for these fisheries by PFRP projects and by the National Marine Fisheries Service to support the fishery management in the Western Pacific Islands Region.

There are three main tasks under this project within FY2006:

A) Technological changes and the impact on fishing effort in the Hawaii-based longline fishery (received funds from PFRP FY2006), Co-PI: Mr. David Itano, JIMAR, Pelagic Fisheries Research Program, University of Hawaii);

B) A longline cost-earnings study on the Hawaii based longline fleet (partially funded by PFRP in FY2003), PI: Dr. Minling Pan; and

C) Blue marine evaluation (received funds from PFRP in FY2003, PI: Dr. Stewart Alan).

Progress During FY 2006

Task A. (1) Completed person-to-person interviews with the owners and captains of 98 longline vessels, accounting for 80% of the total active vessels in 2005, to collect the cost-earnings information during FY2006. The total number of vessels actually targeted for the cost-earnings study was 105 even though total active vessels were 122. Some vessels were included into the study because they were newly entered the fishery and their individual total fishing trips in 2005 were less than 2 trips, or they had exited the fisheries when the fieldwork was conducted in 2006. Therefore, the actual response rate

A research surveyor conducting interviews in a Hawaii Longline Vessel—Economic Fieldwork Study 2006.

for this study was over 90%. (2) Completed database design and data entry with all data collected from the fieldwork.

Task B. (1) Completed the fieldwork study that was designed for investigating the fishing technology status and the cost and time course of technological changes in Hawaii based longline fishery. Captains and owners of 86 longline vessels (80% of 120 total vessels) were interviewed. (2) Completed database design and data entry with all data collected through the fieldwork. (3) Conducted statistic analysis to identify the important elements associated with fishing technology in determining effective fishing efforts and to investigate enhancement of the established technology and vessel or gear attributes to fishing operations and productivity

Task C. (Dr. Stewart Alan is responsible for the task, a progress report is submitted separately.)

Economic Value of Pacific Blue Marlin in the Hawaii Recreational Fishery

P.I.: John Sibert [Stewart Allen]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of the project is to develop estimates of the economic value associated with blue marlin caught by recreational fishermen in Hawaii. This will allow comparison of economic values of recreational blue marlin fishing, for which there is no market, with commercial values, for which a market is established. The results will enable fisheries managers to better compare recreational and commercial values associated with blue marlin.

Progress During FY 2006

The process for collecting the data has been substantially modified and improved, with the result that substantial progress has occurred in FY2006. In the FY2005 annual report, we described difficulties in obtaining a contractor to conduct the study. An added obstacle was that conducting a survey of recreational blue marlin fishermen would have required approval by the Office of Management and Budget (OMB) under the Paperwork Reduction Act, typically a time-consuming process. Both of these barriers have been overcome because the data will now be collected as a component of the socioeconomic add-on mail survey currently being conducted (FY2006) through the Hawaii Marine Recreational Fishing Survey (HMRFS), which already has OMB approval.

We have been working with NOAA headquarters economist Brad Gentner, economist John Duffield, and HMRFS project manager Jeff Muir to develop and pre-test the blue marlin questions, which will be included as part of the mail survey during the next three waves of mailings (to take place July 2006 – December 2006). An added bonus is that we have been able to incorporate ahi into the questions, allowing us to develop values for those species, as well as adding mahimahi to the charter boat client survey and an "ice chest" catch of varying size pounds to the private boater survey. These values will not only provide a context for interpreting blue marlin values, but will provide a useful independent data set.

In our FY2005 annual report, we identified the following goals for FY2006 and have made progress toward them as described below:

• In the first quarter of FY2006, issue the RFP, evaluate bids, and select a contractor. As described above, the project strategy changed from contracting out the survey to conducting it as part of an existing survey within NOAA Fisheries. Therefore, this objective is no longer applicable.

• Determine the method of administering the survey instrument (e.g., via HMRFS or via an independent survey). We selected HMRFS as the survey administration instrument.

• Identify the sampling protocol for survey administration. The sampling protocol for the existing socioeconomic add-on mail survey to the HMRFS survey was adopted.

Evaluation of Data Quality for Catches of Several Pelagic Management Unit Species by Hawaii-based Longline Vessels and Exploratory Analyses of Historical Catch Records from Japanese Longline Vessels

P.I.: John Sibert [William Walsh, Keith Bigelow]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

This project has continued and expanded upon two earlier Pelagic Fisheries Research Program projects (Distributions, Histories, and Recent Catch Trends with Six Fish Taxa Taken as Incidental Catch by the Hawai'i-based Commercial Longline Fishery, by William A. Walsh and Samuel G. Pooley; Comparisons of Catch Rates for Target and Incidentally Taken Fishes in Widely Separated Areas of the Pacific Ocean, by William A. Walsh and Samuel G. Pooley). This project was intended to provide well-documented and verified catch data sets for Pelagic Management Unit Species. The data sets so generated are expected to prove suitable for use in stock assessments or multispecies modeling in the context of ecosystem-based management. In addition, the project was intended to improve understanding of longline catch data from Japanese vessels in the post-World War II period.

Progress During FY 2006

This project was funded in November 2004, with a scheduled two-year duration. Progress during FY 2006 resulted from continuation of earlier work with istiophorid billfishes (marlins) as the species of primary interest. Specifically, logbook data quality control studies in the aforementioned earlier projects included blue marlin, striped marlin, and shortbill spearfish as species of interest. Results from the current project have demonstrated that all of these species are at times misidentified as black marlin or sailfish (or vice versa). The latter two species are the remaining istiophorids taken by the Hawai'i-based longline fishery and were listed as species of interest for this project. Results have demonstrated that species misidentifications have greatly inflated the nominal catches of black marlin and sailfish in the commercial logbooks from this fishery for the 10-year period March 1994 through February 2004 (black marlin: > +700%; sailfish: > +66%). The corrected data have verified that these species are rare (black marlin) and not common (sailfish) in the catch of this fishery. It was noteworthy that the high rates of sailfish misidentifications were unexpected because this species is quite distinctive in appearance. The evaluations of logbook accuracy and associated corrections for the five billfishes from March 1994 through February 2004 have been completed and the corrected data with full documentation archived at the NOAA Fisheries Pacific Islands Fisheries Science Center. A summary of results was presented at the 57th International Tuna Conference (see below); full results, including corrected catch estimates with prediction intervals, descriptions and estimates of logbook reporting bias, evaluations of under- and non-reporting, and standardized CPUE trends are being prepared for submission to the peer-reviewed journal Fisheries Research. This manuscript will serve as a sequel to a recently published blue marlin paper (Walsh et al. 2005; see below). Finally, corrected catch data for striped marlin have already been used in the stock assessment conducted at the Pacific Islands Fisheries Science Center in November 2005.

There were two impediments to progress encountered during FY 2006. The first was that the patterns of species misidentifications were more complex than expected. In many instances, Species A was logged as Species B, which was logged in turn as Species C, etc. However, these multiple errors often involved fractions of the fish, so that it was not possible to assign all A as B or B as C. As such, the need to identify misidentified fractions of the catch made the task of logbook corrections rather tedious and time-consuming. The second impediment to progress was analytical in nature. The statistical models initially used in the logbook evaluations were updated from Walsh et al. (2005). It became apparent, however, that these models were overparameterized and the resulting bias introduced into their predictions approximated the magnitude of the original logbook reporting bias. This problem required simplification of the statistical models used, but the results obtained after doing so appeared promising in that the revisions yielded improved accuracy, precision, and comprehensibility of results. This

work was presented at the Fourth International Billfish Symposium and submitted for publication in the Bulletin of Marine Science. The consequence of these impediments was that little progress was achieved with respect to analysis of the Japanese longline data. A new PFRP proposal has been submitted and we hope to pursue this area if the project is accepted and time permits.

Fishery Dynamics in the Samoan Archipelago

P.I.: John Sibert [Keith Bigelow, Adam Langley, John Hampton]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The purpose of the project study will concentrate on the dynamics of south Pacific albacore. Major objectives include: 1) analyze the spatial and temporal dynamics and fishery interaction of longline fisheries within and around the American Samoa EEZ, 2) comparison of albacore fishery dynamics in other Pacific Island Countries and Territories (PICTs) longline fisheries and 3) improvements to the regional albacore stock assessment.

Progress During FY 2006

This project was funded in November 2004 with a scheduled two-year duration.

Objective 1: A fisheries researcher was recruited in FY2005 and started working on the project in January 2006. Longline logbook data were merged with oceanographic data (e.g. sea surface temperature, ocean color, dynamic height and subsurface temperature measurements) using spatio-temportal information. The resulting dataset is used to investigate the spatio-temporal variations of the American Samoa based longline fishery. The preliminary exploratory statistical (GLM) analysis conducted indicates that landings are largely explained by vessel size and effort. Since the variability of the data around the mean is large (catch data are skewed) further analysis will be conducted to determine what role oceanography represents in explaining catch and CPUE.

Objective 2: Co-PIs completed an analysis of south Pacific albacore dynamics for the Fiji and French Polynesia longline fisheries. Results indicate that catch and CPUE appear directly related to seasonal fluctuations and trends in fisheries in adjacent EEZ waters are likely to be influenced by similar variations in oceanographic conditions. Inter-annual variation in albacore catch rates were also evident in most of the PICT fisheries. The sustained period of low catch rates that commenced in late 2002 appears to be attributable to inter-annual variation in oceanographic conditions and at a local scale, very high levels of fishing effort appear to be capable of causing localized depletion of albacore tuna.

Objective 3: Considerable reappraisal of the underlying model structure of the south Pacific albacore stock assessment was conducted in July 2005. Investigations of the model structure included: appropriate stratification of the model spatially and by fishery, investigation of the performance of the model to the assumptions of seasonal movement between model regions, ability to estimate age specific natural mortality, and various sensitivity analyses with regard to the assumptions of the number of age classes and initial conditions.

Fisheries Oceanography: Methods to Reduce Sea Turtle-Longline Interactions

P.I.: Thomas Schroeder [John Wang, Yonat Swimmer]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

*(left) Gill nets set in Bahia de Los Angeles, Baja, California Mexico by Aquatic Adventures (collaborating NGO) to study turtles' responses to light and a shark scarecrow. (right) Green turtle (*Chelonia mydas*) caught in gill net in Baja, Mexico by Aquatic Adventures (collaborating NGO) as part of on-going sea turtle bycatch reduction experiments.*

Purpose of the Project

A collaborative investigation is currently underway to characterize sensory abilities in sea turtles so that a comprehensive assessment of potential attractants and repellents may be made. The ultimate goal is to develop modified longline gear or bait that will be effective for catching fish but either undetectable or repellant to sea turtles. Use of such gear could potentially decrease the rate of sea turtle injury and mortality due to fisheries interactions.

Progress During FY 2006

The FY2005 annual report identified the following three goals planned for FY2006; progress toward these goals is discussed below.

- Olfaction research on captive turtles to identify potentially repellent baits. Work on olfaction (plan 1) has virtually ceased since no effective chemical deterrent has been found despite extensive testing. Instead, the project focused on visual deterrent research (see 2), below) as a more promising alternative.

- Identify a visual deterrent that would effectively reduce sea turtle bycatch. In FY2006, the project focused on looking for ways to make the gear and bait less visible or attractive to turtles while keeping the bait attractive to fish (plan 2) by conducting electrophysiological and behavioral studies with scientists from Duke University, University of North Carolina, and University of Queensland. Research on the differing speed and flicker fusion frequency of fish and sea turtles suggested that fish

*JIMAR scientist Dr. John Wang preparing for feeding behavior experiments with captive loggerhead sea turtles (*Caretta caretta*) in Baja, Mexico made available in collaboration with Aquatic Adventures.*

lures (lightsticks) might be developed that appear to fish as flashing between two colors, while to turtles they look steady and blend into low background light. Findings also included that turtles see all the colors fish do and more, plus they can see ultraviolet light which fish can't. Earlier studies showed turtles had aversion to

shark images, and a clear plexiglass shark silhouette which radiates ultraviolet not visible to fish suggested a possible deterrent. In collaboration with Aquatic Adventures in Baha California, we conducted experiments on the feeding behavior and responses to light stick use (nighttime) and the shark "scarecrow" idea (daytime) in hard shelled sea turtles known to interact with fishing gear monitored by Aquatic Adventures. Preliminary data indicated that turtles were equally attracted to fishing gear (gill nets) with and without green light sticks. Additionally, turtles did not appear to avoid fishing gear with shark models attached. Despite the fact that a turtle repellent was not identified, the work demonstrated that Aquatic Adventures could be a useful facility to collaborate with for purposes of rapidly testing gear with captive and incidentally caught turtles.

• Collaborative research will continue with Costa Rican, Brazilian, and Ecuadorian scientists to conduct field trials to determine the efficacy of a proposed mitigation measures (e.g. large circle hooks). Great strides were also made in Latin American gear trials (3), most notably in Brazil, where collaborators in Projeto TAMAR demonstrated reduced loggerhead turtle bycatch in longlines using large (18/0) circle hooks with continued viable swordfish catch rates. Also in Ecuador smaller (16/0) circle hooks were found to be effective in reducing the bycatch of smaller (mostly Olive Ridley) turtles, and in Costa Rica testing of 10-degree offset versus non-offset circle hooks indicated no adverse effects of the offset hooks. In these gear tests, the goal of reducing sea turtle mortality and injury is being achieved.

Fisheries Oceanography: Protected Species Investigation: Marine Turtle Research Program

P.I.: Thomas Schroeder [Stacy Kubis, George Balazs]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of this project includes eleven discrete elements that consist of: 1) research to reduce or mitigate high-seas and coastal fishery bycatch of sea turtles; 2) research on the general biology, life history and ecology of sea turtles in coastal marine habitats and on nesting beaches; 3) monitoring of sea turtle population trends for stock assessments; 4) simulation modeling of long term sea turtle datasets to better understand population dynamics; 5) health assessments and disease investigations with focus on sea turtle fibropapilloma tumor disease; 6) administration of a sea turtle stranding and salvage network for research and live turtle rehabilitation; 7) training, capacity building and sea turtle information exchange with other Pacific islands; 8) educational outreach to the public focused on sea turtle research results; 9) experimentation with

MTRP staff with seven live sea turtles captured at Hanauma Bay, Oahu for health assessment, measurements, tagging and release.

remote viewing digital imagery for sea turtle monitoring and research; 10) maintenance of efficient and secure computerized storage, management, and retrieval of sea turtle research data; and 11) administration of observer training in the collection of sea turtle data aboard commercial longline fishing vessels.

Progress During FY 2006

In the FY2005 annual report, MTRP identified the following goals for FY2006: 1) recruit through JIMAR for a Marine Turtle Research Biologist who will act as a researcher and liaison between the Principal Investigator and program contacts and other agencies; 2) continue research of the pelagic ecology and movements of sea turtles to develop management strategies to reduce fisheries bycatch; 3) continue research on fibropapillomatosis disease, with emphasis on specimens obtained from the Hawaii sea turtle stranding and salvage program; 4) continue research and training with Pacific island and Pacific Rim scientists to promote understanding of the biology, migrations, life history and conservation of sea turtle populations in order to promote population recovery of these threatened and endangered species. Progress toward these goals is discussed below.

MTRP staff retrieving a live stranded tumored green sea turtle from Waialae Beach Park on Oahu.

- As planned for FY2006, the MTRP hired Stacy Kubis for the position of JIMAR Marine Turtle Research Biologist in January 2006. Since her arrival, Stacy Kubis has been involved in and/or conducted all aspects of marine turtle biological research, including salvage, rehabilitation, and necropsy of stranded animals; and field research by capturing these animals for tagging, health assessments, and scientific sample collection.

- JIMAR Marine Turtle Specialist, Denise Parker, continued to participate in the research of the pelagic ecology and movements of sea turtles. Denise Parker manages a Pacific-wide satellite-tracking database, prepares maps, analyses satellite-tracking data, and provides data for publication in peer-reviewed journals.

- Cody Hooven, former JIMAR Marine Turtle Stranding Specialist, managed the Hawaii sea turtle stranding and salvage research program. Cody Hooven coordinated a network of stranding responders on each of the main Hawaiian Islands, developed and conducted training programs, and was responsible for data compilation. Cody Hooven was instrumental in compiling stranding data for a manuscript, currently in preparation, on the trends in marine turtle strandings in the Hawaiian Islands. Denise Parker also worked with a team of pathologists and virologists on a fibropapillomatosis manuscript published in the Journal of Zoo and Wildlife Medicine.

- A total of 3 scientists from the Hawaiian Islands and Japan participated in sea turtle collaboration research and training conducted by the PIFSC Marine Turtle Research Program between July 2005 and June 2006. All JIMAR staff participated in the research and training activities associated with the visiting scientists.

- In addition to the goals listed for FY06, another major accomplishment for JIMAR staff was the completion of a NEPA Programmatic Environmental Assessment (PEA). JIMAR staff successfully coordinated and completed the PIFSC NEPA Workshop held in April 2006, which was instrumental in developing the PEA. Stacy Kubis took the lead in writing the document and collaborated with JIMAR and NMFS staff to complete the PEA. In June 2006, reviewers' comments were addressed and final editorial changes were made. The approval of the Finding of No Significant Environmental Impact (FONSI) was granted in June 2006. The approval of the FONSI permits the transfer of Federal funds to a MTRP JIMAR grant, tentatively scheduled for July 2006, which will provide continued funding for conducting the critical research on sea turtles that has occurred for over thirty years.

Human Dimensions Analysis of Hawaii's Ika-Shibi Fishery

P.I.: John Sibert [Edward Glazier]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The general goal of the project is to provide PFRP and WPRFMC with information needed to optimally manage Hawaii's ika-shiba fishery and associated resources. More specifically, our goals are: to describe how the fishery is configured in social and economic terms; identify and analyze factors that have influenced change in rates of participation and production over time; and describe and explain how and why participants have been implicated in and/or have reacted to such changes.

Progress During FY 2006

All objectives established to meet the goals of this project have been met. However, the research is closely related to the project titled "An Assessment of Small Boat Yellowfin and

Large tuna amidst social scene at Suisan auction, late 1970s (image courtesy of Walter Ikehara).

Bigeye Tuna Operations and Regulatory Scenarios in the Main Hawaiian Islands." In fact, numerous research participants are involved in both projects. As such, a request was made and granted to extend the project period of performance in order to maximize the extent of our research interactions with the full range of informants involved in the study, and to enable ongoing monitoring of the ika-shibi fleet through the duration of the related project. Findings from both studies will inform a single comprehensive report describing and explaining trends in the nature and extent of small boat handline fisheries enacted in the MHI from the pre-contact era to the present.
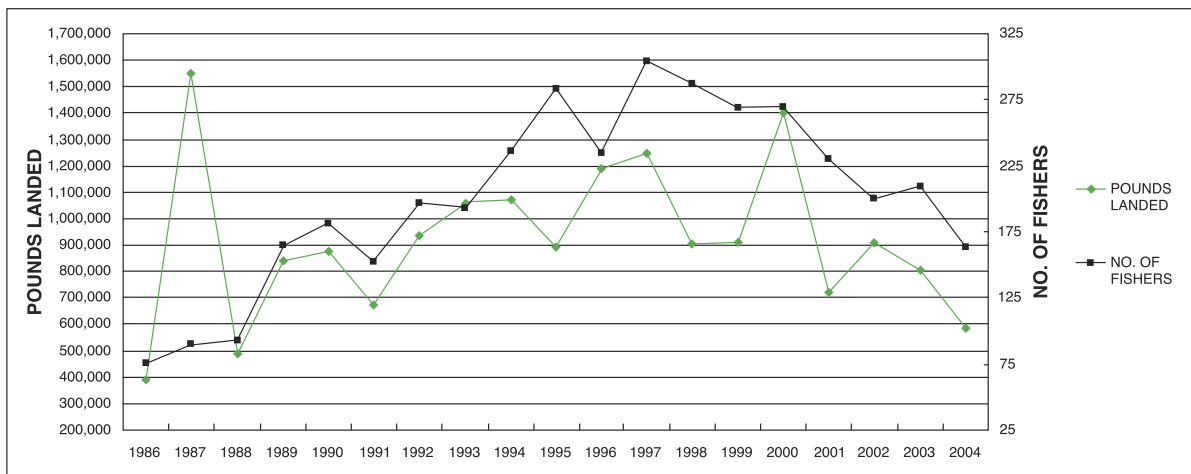
Reported Commercial Landings by Ika-Shibi Method in the MHI: 1986-2004

Incidental catch of Non-Target Fish Species and Sea Turtles: Comparing Hawaii's Pelagic Longline Fishery Against Others

P.I.: John Sibert [John Kaneko, Paul Bartram]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

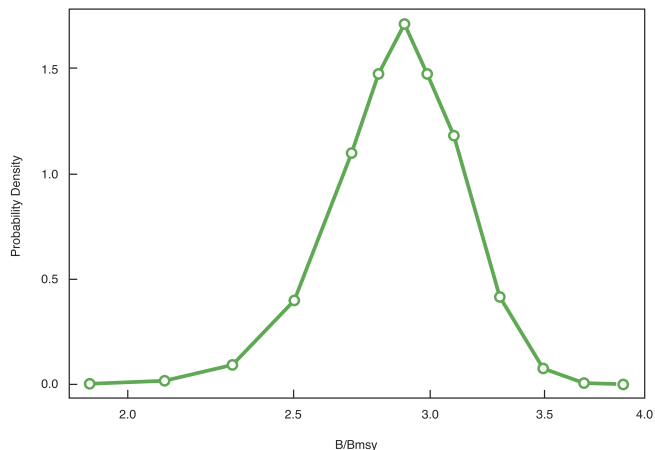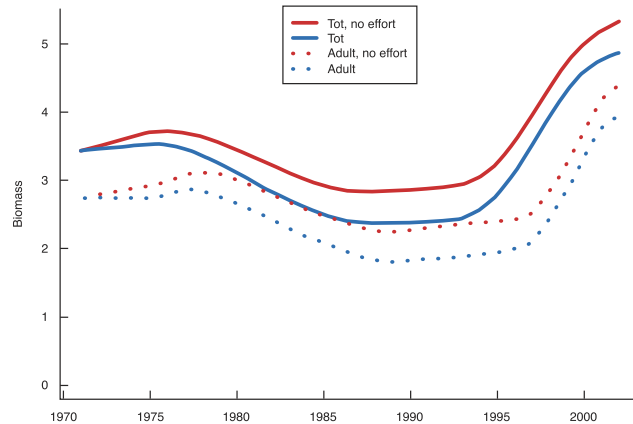• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The purpose is to evaluate the incidental catch rates of non-target fish species and sea turtles in Hawaii's longline fishery and make comparisons with other pelagic longline fisheries using a methodology patterned after Hall (1999). The final report titled: Catch to Bycatch Ratios: Comparing Hawaii's Longline Fisheries with Others, was prepared and distributed as SOEST 0-05 JIMAR Contribution 04-352. Later in 2005, an extension of the project was awarded. The purpose of the extension is to develop (where possible) pelagic longline gear profiles of Japanese and Taiwanese longline fleets in the WCPO producing ULT frozen sashimi bigeye tuna. Efforts will be made to expand (where possible) the pelagic longline profiles to include information on the number and size of vessels, fish hold capacity, type of refrigeration/freezer, target species and target market in addition to the information on gear and fishing practices.

Progress During FY 2006

We proposed a combination of desk-based work and travel to contact international tuna fishing organizations, fishing industry members and fishery management organizations to attempt to identify and obtain the information needed for the fleet profiles. We attended the Third International Fishers' Forum, July 25-28, 2005 in Yokohama, Japan to take advantage of the opportunity to interview fishers from various fleets and other conference participants that will be assembled.

(top) North Pacific blue shark total and adult biomass estimated by MULTIFAN-CL. Lines labeled "no effort" are estimates of what biomass would have been in absence of fishing. (bottom) Likelihood profile for ratio of biomass to biomass at MSY estimated for North Pacific blue sharks by MULTIFAN-CL.

Contacts were made with representatives of Taiwanese and Japanese ULT freezer longline vessels. Several interviews were completed, with follow-up from Honolulu to clarify information provided. As anticipated, collecting this information has proven to be difficult. More information is needed from the Taiwanese fleet, making a trip to Kaohsiung, Taiwan necessary. This trip has been postponed due to scheduling conflicts with our local contacts and bilingual tuna industry specialist.

Incorporating Oceanographic Data in Stock Assessments of Blue Sharks and Other Species Incidentally Caught in the Hawai'i-based Longline Fishery

P.I.: John Sibert [Pierre Kleiber, Hideki Nakano]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

Improve habitat-based standardization of longline effort by accounting for the affects of current shear and other oceanographic features on the depth distribution of longline hooks and the degree to which that distribution overlaps the depth distribution of particular fish species.

Progress During FY 2006

Plans for FY 2006 were to contract with Otter Research Ltd. to add enhancements to MULTIFAN-CL (MFCL), the principal stock assessment model that is making use of standardized catch and effort data analyzed by this project. This contract has recently been established, and a working session was recently held with Otter Research, the PI (Pierre Kleiber), and John Hampton, the PI of a related PFRP project. Addition of multi-species capability, sex structure and other enhancements to the length-based, age structured modeling software MULTIFAN-CL.

Instrumented Buoys as Autonomous Observatories of Pelagic Ecosystems

P.I.: Kim Holland

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

To design and test a prototype research buoy that is capable of using active echo-sounding techniques to observe the community of pelagic organisms that aggregate around floating objects. The sonar will be capable of 360-degree sweeps around the buoy. Data collected by such an automated observatory will increase our understanding of the pelagic ecosystem and improve management capabilities. New types of transmitters that might be used in conjunction with such an observatory are to be evaluated and, where appropriate, built and tested.

Progress During FY 2006

The various components for the instrumented buoy continued to be assembled by the principle subcontractor (Dr. Jules Jaffe, Scripps Institution of Oceanography). The electronic components have been assembled and tested in the laboratory and soon will be tested in a test tank. The external mechanical components of the instrument have been purchased. Several potential new tag types were tested (bioacoustic probe, accelerometer tag, stomach motility tag and stomach acidity tag). The latter was sufficiently successful as to warrant further development into an active acoustic transmitter that will telemeter stomach acidity data in real time.

Integrated Modeling for Hawaiian Albatross Populations

P.I.: John Sibert [Dan Goodman, Jean-Dominique Lebreton]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The purpose of the project is to analyze available information concerning Black-footed (*Phoebastria nigripes*) and Laysan (*Phoebastria immutabilis*) albatross (BFAL and LAAL for the sake of brevity in what follows). These analyses aim at assessing the status of their populations in relation with the potential impact of longline fisheries. While BFAL population size is about one tenth of LAAL's, the ratio of by-catch by longline fishing is higher. This suggests a high impact of longline fishing on BFAL, with potential biologically significant consequences. Due to the uncertainty on population size (roughly 300,000 individuals), and the level of by-catch in the 90s (between 5000 to 12000 individuals), up to now the impact of by-catch on population dynamics and sustainability in BFAL remains unknown, although such a level is considered on general grounds as high enough to be detrimental. Furthermore, little is known about the demography and biology of both BFAL and LAAL, for example for what concerns age and rate of recruitment, adult and juvenile survival, and rate of pair reformation after widowhood.

The project is divided in three main steps.

• Estimation of demographic parameters by capture-recapture analysis of existing data and analysis of census data

• Integration of these pieces of information in a matrix model, integrating as much biological specificities as possible, such as intermittent breeding, widowhood and time to repair.

• Last, development of integrated models, using in particular the Kalman filter and Bayesian approaches, to combine likelihoods for the various pieces of information available.

Whitetip XYZ logger deployment
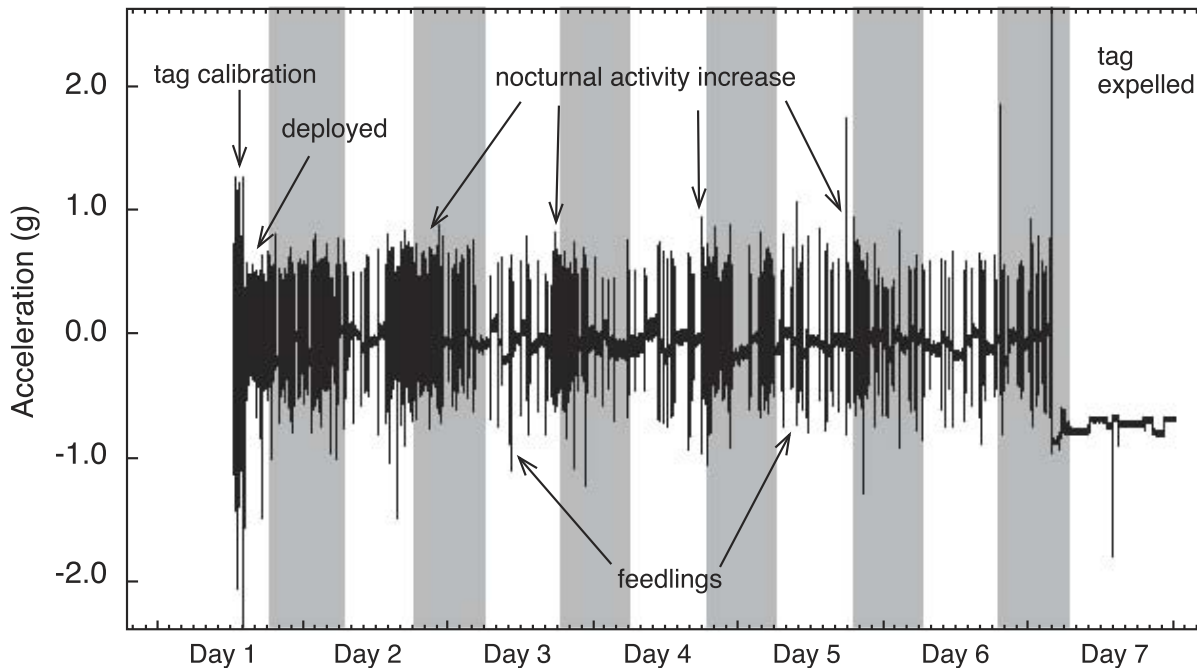
Six days of shark activity measured by accelerometer tag

Progress During FY 2006

• Compilation of data. A large part of the year was used to finalize the compilation of information required for the analysis. This included updating capture-recapture data of BFAL and LAAL, getting data on fishing effort and on recoveries of ringed animals caught by Hawaiian fleet. We also met people from the Pacific Fish and Wildlife Service involved in albatrosses project, in order to obtain more details on study design and sampling methods.

• Analyses of capture recapture. We started the analysis of capture-recapture data for adults BFA using models with heterogeneity in capture probability developed in our laboratory. Without the use of these models, the survival estimates are underestimated. As a first approach, we performed the analysis using a model where survival was constant over time. We confirmed the existence of heterogeneity in recapture probability (survival estimated at 0.903 in a classical model versus 0.92 when taking into account heterogeneity). All analyses were performed using software U-CARE and M-SURGE.

• Estimation of by-catch. A major source of uncertainty comes from the estimation of by-catch rate. Up to now, estimation of by-catch was direct, relying on counting the number of animals caught on boats with observers, extrapolating to American fleet and to other fleet. An important source of variance in the estimation of by-catch comes from the extrapolation to a large scale. We plan to estimate the by-catch rate using another method relying on the combination of capture-recapture and recoveries data. This estimate will be used for validating the former estimation method for obtaining more accurate estimates. It thus could be used in the future as a useful and powerful tool for the management of by-catch rate. In practice, we built a multi-state capture-recapture model that includes recoveries of caught birds by boats with NOAA observers.

• Integrated modeling. We collaborated with Mark Maunder and Simon Hoyle of the IATTC, involved in a PFRP project of "general Bayesian integrated population dynamics model for protected species." We established a common capture-recapture model and matrix model that we plan to use as a common framework for integrated modeling.

Integrative Modeling in Support of the Pelagic Fisheries Research Program: Spatially Disaggregated Population Dynamics Models for Pelagic Fisheries

P.I.: John Sibert

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The general objective of this research is to integrate the results of different components of the Pelagic Fisheries Research Program into a consistent framework that integrates knowledge of fish movement and population dynamics, the fishing process, economics and oceanography. The primary focus is the development of spatial models of pelagic fish population dynamics that explicitly include movement, mortality, and fisheries. The work emphasizes collaboration with other PFRP projects.

Progress During FY 2006

Progress on goals from FY 2005:

• *Analyze currently used light-based geolocation algorithms to identify and correct the source of the autocorrelated latitude bias.*

The bias in light-based geolocation estimates appears to be related to misspecification of the solar elevation that defines sunrise and sunset for an archival tag, misspecification of solar irradiance at that elevation, and errors in measuring irradiance.

Work was begun to construct a statistically sound approach to geolocation and reconstruction of tracks from animals tagged with light archiving tags. This includes the formulation and implementation of a joint

model for the geolocation from light measurements and prediction of the most probable track from these measurements.

This project has developed and implemented a joint model for the geolocation from light measurements and prediction of the most probable track from these measurements. The model has been successfully tested on several tags attached to moorings. Depth correction is not included in the model yet, but the functional relationship between depth and light level is well understood, and this is expected to be a minor addition to the model. The model is promising, as it is able to provide accurate tracks for tags where the other methods have failed (see attached figure). The model is completely self contained, which means that it does not depend on code or pre-calculated geolocations from the tag manufacturers. In addition, the developed model makes it possible to estimate confidence regions of the reconstructed track, without assuming some arbitrary seasonally varying latitude variance model.

In developing this model, there were two time demanding key issues. 1) Approximating the relationship between solar altitude angle and measured light intensity. 2) Selecting a computationally feasible estimating procedure to estimate model parameters and reconstruct the track. Both of these issues were resolved by comparing numerous solutions.

- *Refine the inclusion of temperature in the Kalman filter model*.

The kfSST statistical package was updated to include automatic retrieval of SST data from the World Wide Web. Graphics capabilities of the package were enhanced and the option to produce interactive track maps using Google Maps (https://www.soest.hawaii.edu/tag-data/map/) and Google Earth utilities were also included.

This project continues to maintain and develop the two software packages 'kftrack' and 'kfSST,' which are used by many scientists to improve their tracks. Collaborations with numerous excellent scientists are ongoing, which benefit this project by providing inside information about real data challenges, and benefit them by improving their geolocation tools.

- *Creation of electronic tagging data repository*.

The Electronic Tagging Data Repository was redesigned and given a new URL: https://www.soest.hawaii.edu/tag-data/

The repository now contains the following data

Data	Owner	No. of Tags	Access	Type Of Data
Hawaii Mooring	Musyl	5	Public	Raw data
Bigeye Acoustic	Holland	2	Public	Raw data
Horizontal Movement of Bigeye Near Hawaii	Sibert	11	Public	Processed position of estimates
Vertical Movement of Bigeye Near Hawaii	Musyl	9	Public	Raw data
Coral Sea Bigeye	Gunn, Hampton	15	Restricted	Raw data
PSAT-Performance and data recovery	Musyl	>650	Restricted	Data on shedding
New Caledonia Mooring	Leroy	2	Restricted	Raw data
French Polynesia Acoustic	Dagorn, Josse, Bach	20	Public	Raw data
Indian Ocean Acoustic	Marsac, Cayré	10	Restricted	Raw data

- *Collaboration on the "Mixed-resolution models for investigating individual to population spatial dynamics of large pelagics" project*.

Implementation of parameter optimization in SEAPODYM is nearly complete. Initial results indicate the parameters estimated by maximum likelihood methods greatly improve correlation between prediction and observation in both time and space domains. The estimated parameters will be of use in long-term simulations. A more complete description of progress on this topic can be found in the "Mixed-resolution models for investigating individual to population spatial dynamics of large pelagics" project progress report.
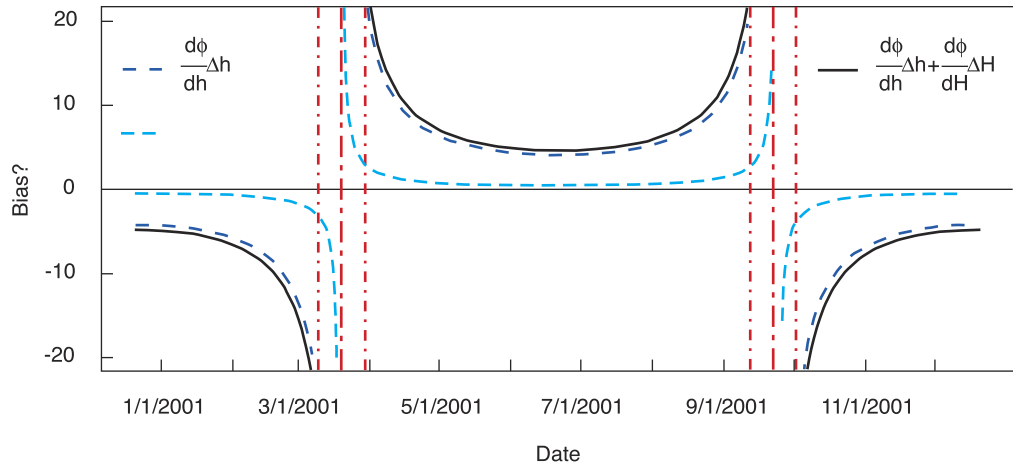
Theoretical latitude estimation bias, solid black lines, at the latitude of Honolulu produced by a 2 minute sunset estimation error and a 2 degree misspecification in solar elevation at sunset. Vertical dashed lines indicate approximate dates of vernal and autumnal equinoxes and 10 day intervals before and after.
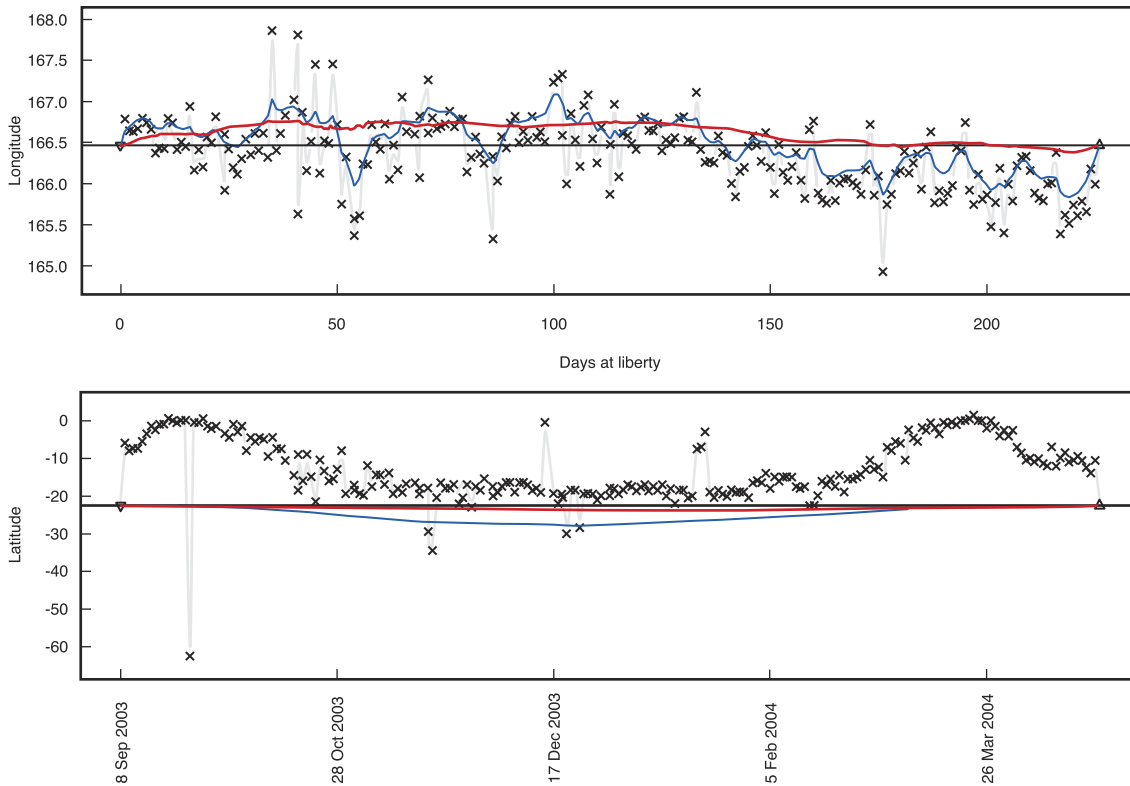
Reconstructed longitude and latitude of a tag attached to a mooring. The horizontal gray line is the known true position, the positions marked by 'x' are raw geolocations supplied by the tag manufactures, the thin blue line is the reconstruction from the two step approach, and the thick red line is the reconstruction from the joint model.

Long-Term Deployment of Satellite Tags on Swordfish Using the California Harpoon Fleet

P.I.: John Sibert [Heidi Dewar, Jeffrey Polovina]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

• To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

Swordfish support an economically important international fishery. Despite the commercial importance of this species there is still limited information on their large-scale movements and behaviors, which are necessary to define stock structure and manage the resource. Although there have been a number of attempts to identify stock structure using fisheries statistics, genetics and conventional tags, stock structure in the Pacific is still unclear. More recent efforts using electronic tags have been hampered by the high mortality rate associated with catching fish on a longline. The goal of this study is to test the potential for using the harpoon fleet in the Southern California Bight to deploy pop-up satellite archival tags for periods of 6 to 10 months. The mortality from the harpoon fleet is minimal.

Progress During FY 2006

The goal for 2006 was to deploy a total of 12 PAT tags, half at the beginning and half at the end of the season. In addition, half of the tags were to be rigged with one dart type and the other half with a second dart type. Although funding did not come through until November we were able to deploy 10 PAT tags on swordfish in 2005. Because of the delay in obtaining funding it was not possible to deploy tags at the beginning of the season and all tags were deployed from September through December. In addition, due to problems with the injection mold process the second dart type was not available for use so only one dart type was used.

Of the 10 tags deployed, 3 tags popped up and reported to satellite. The data from one of these tags indicated that the fish died shortly after the tagging event. The first mortality documented from the harpoon fleet. The remaining two released after 24 and 103 days (left, top). The data analysis on the second two tags is ongoing.

(right) The release and recapture locations for the two tags that popped up in 2005 after 24 and 103 days. Intermediate locations were calculated from light levels and sea surface temperature for the longer deployment.
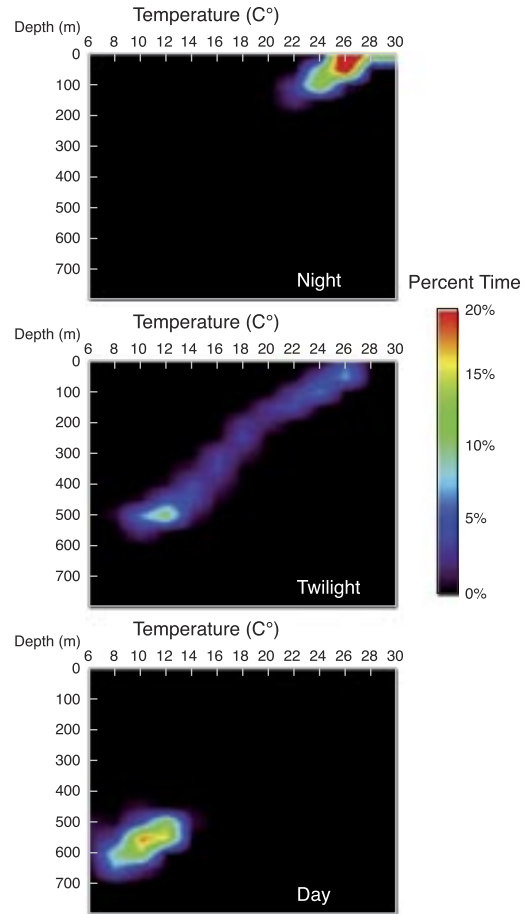
(above) A representative vertical habitat envelope showing the most prevalent depths and temperatures occupied by the swordfish during the night, at twilight and during the day. Note the distinct difference between day and night.
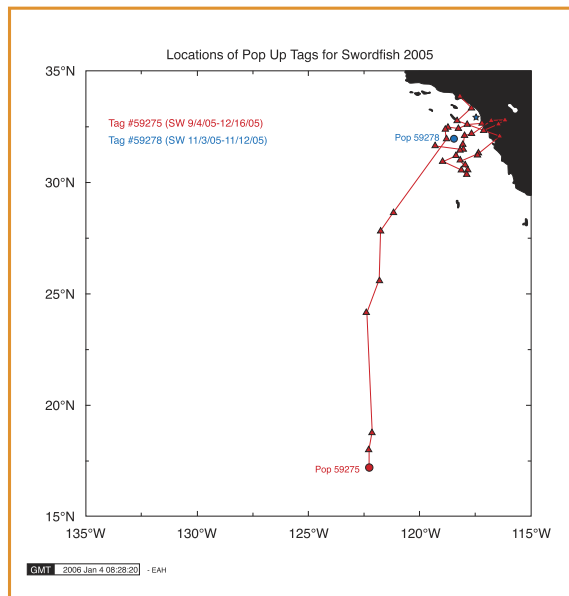
Fisheries Oceanography: Marine Mammal Research Program

P.I.: Thomas Schroeder [George Antonelis]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of the Marine Mammal Research Program (MMRP) is to study the relationship between environmental/oceanographic parameters and demographic trends of the endangered Hawaiian monk seal and cetaceans in the Pacific Islands Region (PIR). Monk seals and cetaceans are apex predators and represent important components of the marine ecosystem. Much is known about monk seal population dynamics, and monitoring programs are in currently place. The project has recently begun to collect scientific information on cetacean stock identification, abundance, and population trends in PIR to fully characterize cetaceans' role in this highly complex environment. By obtaining a better understanding of the environmental factors

JIMAR Research Supervisor Maire Cahoon collects monk seal scat sample for dietary analysis.

that directly and indirectly influence marine mammals' population growth, managers will be able to make more informed decisions concerning ongoing conservation and recovery efforts.

Progress During FY 2006

The MMRP addressed monk seal population monitoring and assessment, characterization of foraging ecology, and evaluation of health and disease. In the FY2005 annual report, two specific goals were articulated for the program; progress towards these goals is discussed below.

1) Monk seal assessment studies will expand in the Main Hawaiian Islands due to an apparent increase in their numbers within this portion of their range. This has been accomplished. A full time sightings coordinator has been hired; a cadre of responders has been trained to collect data whenever seals are reported in the MHI; and historical and current MHI sighting data have been entered into a database.

In addition, the health and disease project trained a full complement of 15 field researchers in seal necropsy and sampling techniques, and processed the resulting samples from the field season.

2) Complete a comprehensive cetacean research plan for PIR based on the results from the FY2005 cetacean workshop. The results from the FY2005 cetacean workshop were prepared, and are being used to finalize a cetacean research plan for the Pacific Islands Region. While the substance of the document was finalized in FY2006, the publication itself will not be final until FY2007. This is because the publication contains special features (e.g., a large number of graphics) that are taking some time for PIFSC's Scientific Information Services to develop and craft into a cohesive document. The cetacean biology investigation also completed a survey of cetaceans in the waters of American Samoa and Johnston Atoll, and deployed a high frequency acoustic recording package (HARP) off Palmyra Atoll to monitor occurrence of cetaceans in that area. Collaborative efforts were also initiated to collect biopsy samples from cetaceans in the NWHI.

Marine Resource Dynamics and Assessment Program (MARDAP): Cooperative Research

P.I.: Thomas Schroeder [Michael Musyl and Christofer Boggs]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The project was originally funded to instigate and coordinate cooperative research between the National Marine Fisheries Service (National Marine Fisheries Service) scientists and the fishing industry, fishery managers, and academic researchers by encouraging collaboration, improving communication, and using the fishermen's expertise and vessels to answer scientific questions of immediate importance to industry and managers. In 2004, funds were added specifically to research marlin bycatch reduction in the Hawaii tuna longline fishery. NOAA's Reducing Bycatch Program provided these funds.

Diagram showing configuration details of deep-set gear technique that deploys weights between floatlines and branch lines to hold all branch lines below 100m.

Progress During FY 2006

As planned, funds were used to contract a commercial longline vessel to participate in the bycatch reduction experiment, to purchase the necessary gear to conduct the research, and to contract the services of Mr. Steve Beverly to teach the vessel's crew the deep-setting technique. By a competitive bidding process, a longline vessel was selected to deploy 90 sets of 2200 hooks each, of which 45 sets will be control and

Deployment of the deep-set gear fishing deeper than 100m avoids epipelagic bycatch species (e.g. marlins) and effectively targets bigeye tuna.

45 will be treated (i.e., deep-set gear). The vessel left in mid-June 2006 to start the project and it is expected that the data collection phase of the project will be finished in November 2006 (ca. 7 months later than projected in 2005). The delay in starting was due to inexperience with the vessel contracting process, and the preliminary report planned for the 2006 Tuna Conference will be given next year. Preliminary results on 14 sets (i.e., 7 treated vs. 7 control) conducted from 14 June to 3 July, 2006 indicate that the deep-set gear captured 1.5x the amount of bigeye tuna (target species) as compared to the control sets. The deep-set gear also caught about one-half as much incidental catch and bycatch (anything other than bigeye tuna) as the control gear. Control and treated sets are deployed in virtually the same location on consecutive days, so that environmental effects between the two kinds of sets are minimized, and the two methods can be compared pairwise for differences in catchability. The very promising initial results are a strong step towards the project goal of demonstrating substantial reduction in the catch of marlin and other epipelagic species through cooperative research with the longline industry.
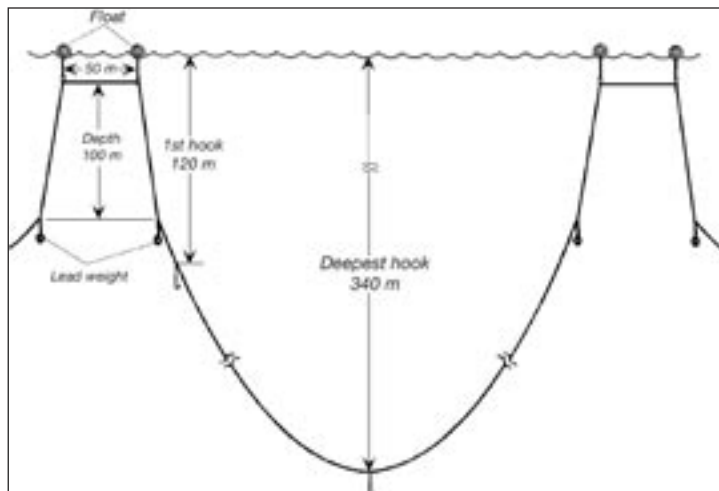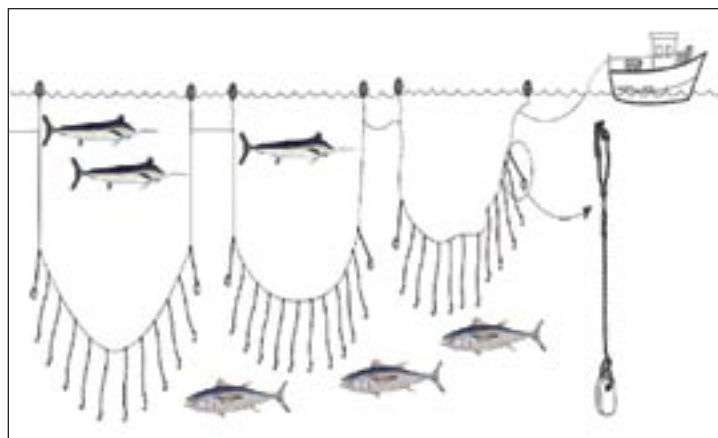
Marine Resource Dynamics and Assessment Program (MARDAP): Economics of Fisheries Initiative

P.I.: Thomas Schroeder [Minling Pan]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

Initiated in July 2000, this research program focuses on economic assessment of commercial and recreational fisheries. The program's objectives in FY2006 were as follows.

• Investigate the volume and price of carbon monoxide (CO)-treated tuna imported into Hawaii via transshipment through the U.S. mainland

• Support the ongoing economic data collection program to assess changes in key economic indicators in the Hawaii longline and Northwestern Hawaiian Islands (NWHI) bottomfish fisheries

• Since the current economic data collection through the Hawaii longline fishery observer program is limited to data on trip costs, a fleet-wide economic data collection including annual expenditures was proposed in FY2005 to investigate the annual basis of costs and earnings for the Hawaii longline fleet

• An additional task was to explore the possible options for establishing a continuous economic data collection program for the American Samoa longline fishery.

Progress During FY 2006

The main goals of this FY2006 were achieved as follows.

• Compiled time-series data for the importation into Hawaii of tuna landed in foreign countries. A draft analysis describing the impact of imported tuna on the fresh tuna market in Hawaii was completed. The analysis found that majority of imported tuna arrives in Hawaii via transshipment through the U.S. mainland. However, because there are no official records of transshipments, an analysis of the total volume and value of tunas imported to Hawaii could not be performed. As a result, the project explored approaches for collecting the data on volume and price of CO-treated imported tuna (e.g., through contacting importers). This research suggested that establishing a monitoring system is a possible option for collecting these data.

• Continued the on-going effort to assess changes in key economic indicators through the existing monitoring program. Trip expenditure data from a total of 360 longline trips were collected through the observer program in the period July 1, 2005 to June 30, 2006. A draft report on the first year of the economic data collection add-on to an existing data collection system is under preparation. This report documents the process of establishing the data monitoring system and presents a summary of the economic data (mainly trip expenditure) collected through the monitoring program.

• Conducted and completed fieldwork in 2006 for the cost-earnings study of Hawaii longline fleet. A total of 98 vessels, representing 93% of vessels targeted in the survey, responded to the person-to-person interviews. The resulting survey data were entered into a database.

• Worked with the observer program in the Pacific Islands Regional Office (PIRO) to establish the data collection program in America Samoa. The observer program in America Samoa started in March 2006 and the program is still in the testing stage. As a result, it hasn't been possible to integrate economic data collection into the observer data collection protocol.

The main goals of this FY2006 were achieved.

Marine Resource Dynamics and Assessment Program (MARDAP): Lobster Research Program

P.I.: Thomas Schroeder [Gerard DiNardo]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The goals of this program include assessment of: (1) the status of insular resources in the Pacific Islands Region (i.e., bottomfish and spiny and slipper lobster stocks in the Northwestern Hawaiian Islands (NWHI)); and (2) the impact of fishing on these stocks. The program was initiated in response to a technical review of the NWHI lobster assessment procedures, where it was recommended that collaborative research programs between industry, the PIFSC, and the University of Hawaii (UH) be developed to: (1) provide independent estimates of population size; (2) generate updated estimates of population dynamics; (3) further our understanding of the ecological role of lobsters in NWHI ecosystem; and (4) advance crustacean stock assessment methodologies.

In FY2005, the scope of the program was expanded to address a third goal: assess the status of pelagic stocks in the Pacific Ocean. Assessments of pelagic stocks are conducted collaboratively with scientists from Japan, Taiwan, Korea, Mexico, and the Inter-American Tropical Tuna Commission under the

Scientists taking measurement of carapace length of slipper lobster prior to PIT tagging.

auspices of the International Scientific Committee (ISC). Priority is given to billfish and oceanic shark species in the Pacific Ocean, including marlins, swordfish, and blue shark.

Progress During FY 2006

The JIMAR FY2005 annual report outlined five goals for FY2006, including: 1) continue spiny and slipper lobster tagging experiments at Necker Island and Maro Reef; 2) conduct the NWHI lobster resource survey in June 2006; 3) if feasible, expand the spatial scope of the NWHI lobster resource survey and tagging experiments to archipelago-wide; 4) participate in the American Fisheries Society 136th Annual Meeting, scheduled for September 2005 in Anchorage, AK; and 5) complete pelagic (blue shark and striped marlin) and insular (NWHI lobster and bottomfish) stock assessments, and advance population model development.

Of the goals articulated, the following were accomplished:

• Lobster tagging. Three commercial fishing vessels were contracted (chartered) in FY2006 to conduct lobster tagging experiments. Two vessels were chartered from July 16-August 15, 2005 and conducted tagging operations at Necker Island and Maro Reef. One vessel was chartered from June 8-July 7, 2006 and conducted tagging operations at Necker Island and Gardner Pinnacles. JIMAR staff provided oversight on all scientific elements of the experiments. The 2005 charters were a success; approximately 7,000 spiny lobsters at Necker Island and 6,000 slipper lobsters at Maro Reef were tagged and released. The 2006 charter was not completed at the time this report was written, but all indications suggest a successful cruise. Current tagging data were analyzed to estimate spiny lobster growth and movement patterns, and these estimates compared to historical growth patterns.

- NWHI lobster resource surveys. The 2006 NWHI lobster resource survey was conducted from June 5-July 4, 2006 aboard the NOAA R/V Oscar Elton Sette. During the cruise, a suite of experiments and data collection activities were conducted by both PIFSC and JIMAR scientists. Data from the survey are being edited and keypunched. In addition, bycatch associated with the NWHI annual lobster resource survey was analyzed to determine the utility of using these data to assess fishing impacts to the NWHI ecosystem.

- Archipelago-wide lobster resource survey. The spatial scope of the tagging experiments was expanded in FY2006 to include Gardner Pinnacles, Laysan Island, and North Hampton Seamount.

- Participation in the American Fisheries Society 136th Annual Meeting. Considering our funding constraints, we determined that the funds that would have been used to cover the cost of attending the meeting would be better used to fund research activities. As a result, we did not send anyone to the meeting. However, numerous presentations on the status of lobster research were presented by JIMAR staff to the Western Pacific Fisheries Management Council (WPFMC).

Scientists inserting PIT tags into spiny lobster.

- Complete pelagic and insular stock assessments and advance population models. Numerous stock assessments were completed by JIMAR staff and significant progress on population model development also occurred in FY 2006. A spatially-explicit population model for spiny lobster that incorporates all available fishery-dependent and fishery-independent data was developed in collaboration with scientists from the University of British Columbia. Similar work is preceding with deep-slope bottomfish stocks in the Hawaiian archipelago. This is the first spatially structured population model for NWHI lobster populations, and represents a significant advancement in our understanding of local and regional dynamics. In addition, subcontractor Dr. Shelley Clarke, stationed at the National Research Institute of Far Seas Fisheries (NRIFSF) in Shimizu, Japan, completed the blue shark assessment in August 2005 and the striped marlin assessment in March 2006.

Marine Resource Dynamics and Assessment Program (MARDAP): Research Support

P.I.: Thomas Schroeder [Susan Kamei]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of this project is to continue to provide research and administrative support for fishery data monitoring and research operations as part of the ongoing research under the Marine Resource Dynamics Assessment Program (MARDAP).

Progress During FY 2006

Project funds supported ongoing research operations conducted at the Pacific Islands Fisheries Science Center (PIFSC) on the University of Hawaii campus and at the Kewalo Research Facility. The following is a summary of progress in each area.

Facilities Maintenance

The maintenance assistant provided considerable logistical support of major facilities projects as identified as an objective in FY2005. These projects included the oversight of the transfer of various materials into a consolidated storage facility, oversight of air conditioning repair and duct replacement, sprinkler system repair, installation of an office trailer, and replacement of main entrance conference room doors to meet fire code standards. All goals set for this project period were met.

Administrative Support

Due to turnover, the administrative associate position was vacant from August 2005 until a replacement was found in April 2006. The replacement position was filled at a slightly higher level and the incumbent will take on new duties, including meeting coordination, rapporteuring, and project management. Although this position was vacant for a significant amount of time, the newly placed associate has made notable progress in learning procedures and protocols and is already providing a wide array of administrative services to the project.

Web Services

As proposed, the Webmaster implemented the Web Development Plan and directed the newly created Web Team. As proposed, the Webmaster maintained and expanded Web pages and provided direct technical support for delivery of data products and other dynamic Web content. As proposed, the Webmaster routinely reviewed and revised Web practices to ensure conformance with NOAA and other guidelines.

Scientific Editing

As proposed, the Scientific Editor provided comprehensive professional editing services to program staff, completed a review of editorial policies and procedures and made essential changes. As proposed, she worked with Scientific Information Services technical staff to establish design requirements for an online (Web-based) system for handling manuscript submission, review, editing, and approval. As proposed, the Scientific Editor upgraded the tools used for in-house publishing, migrating from Microsoft Word software to Adobe InDesign software and created new templates for our Administrative Reports and NOAA Technical Reports.

Fishery Monitoring

As proposed the specialist continued logbook collection, vessel monitoring, maintenance of the current vessel inventory, and liaison duties. This year, all swordfish trip and trips in the Eastern Pacific Ocean were fast-tracked due to the big eye tuna quota in place. The specialist responded to 5-10 requests for fishing trip information weekly from the debriefers and responded to all requests from the Office of Law Enforcement. Goals planned for this project period were accomplished.

Marine Resource Dynamics Assessment Program (MARDAP): Sociocultural Profile of Pacific Islands Region Fishing Ports

P.I.: Thomas Schroeder [Stewart Allen]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

Part of the ongoing research under the Marine Resource Dynamics Assessment Program (MARDAP), the purpose of this project is to develop a social and cultural data base of fishing ports and associated communities in Hawaii, Guam, Commonwealth of the Northern Marianas, and American Samoa. The goal is to provide a standard set of information for Western Pacific fishing communities and ports that is consistent with profiles currently

being developed in other parts of the country. The information generated will be used to assess the effects of fishing regulations and other actions on social and cultural aspects of fisheries. Comparison of Western Pacific ports with other ports nationwide also will allow us to document the unique social and cultural aspects of Western Pacific fishing activity, as well as reveal commonalities.

Progress During FY 2006

In our FY2005 annual report, we identified the following goals for FY2006 and have made progress toward them as described below:

- *A draft of a NOAA technical memorandum providing profiles of fishing communities will be available October 2005.* Although much of the report was developed in draft, we made the decision to finish the report following completion of the sub-fishing community scale analyses for Hawaii and Guam (described below). Producing the resulting report will be the highest priority for the new JIMAR social research project manager/researcher position currently being hired (position closed on July 1; individual has not yet been selected but is expected to begin work by September 2006).

- *Continue fieldwork in Guam under a contract between NOAA and a consultant with experience working with Guam fishermen and communities.* The contract is currently being finalized but calls for a report describing Guam fishing communities by July 1, 2006. The contract was finalized and work is proceeding. The draft report from the contractor is expected by the end of this fiscal year.

- *Seek funding for additional fieldwork in CNMI and/or American Samoa. Funding for the American Samoa fishing community profile was sought as part of the socioeconomic component of a broader request for funding (American Samoa Coral Reef Ecosystem Studies proposal to the Center for Sponsored Coastal Ocean Program).* On April 7, 2006, we were informed that the overall project had not been funded.

Mixed-Resolution Models for Investigating Individual to Population Spatial Dynamics of Large Pelagics

P.I.: John Sibert [Patrick Lehodey]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

This project addresses ways to improve upon two classes of models: Individual Based Models (IBMs) and Advection Diffusion Reaction Models (ADRMs) that can provide complimentary approaches to investigating the problems of scale integration when going from individual to the population level and from individual movements to advection-diffusion patterns. However, the approach needs a unifying framework combining large and small spatio-temporal scales i.e., the mixed resolutions in a same model domain. Therefore, the project proposes mathematical and programming developments in movement and spatial population dynamics models. The ESSIC model (co-P.I. R. Murtugudde, Univ. Maryland) will provide fields of predicted data (currents, temperature, primary production and zooplankton biomass). These predicted data will serve as input in the spatial ecosystem model (SEAPODYM) that will predict the oceanic environment of tuna (prey fields) and the large scale dynamics of their populations. Observed movements of individual tuna marked with electronic tags in selected study areas will be used to evaluate the models, and analyzed to enhance the mechanisms of both IBMs and ADRMs.

Progress During FY 2006

Activities conducted in FY 2006 corresponding to those planned in last year report are listed below:

- Thanks to mathematical and code development by Dr. Inna Senina, at the PFRP, the model SEAPODYM is

fully operational in a mixed-grid mode. The associated software GMB developed to define the grid and mask has been enhanced. This allows us to interpolate SEAPODYM input data (environmental and fishing data) onto constructed grids.

- Parameters of mid-trophic (forage) components of the SEAPODYM model have been scaled against available information. Simulation at 1/2 deg x 10 days resolution for 1948-2004 is available. Further evaluations will be conducted opportunistically as new observation will become available (in particular acoustic survey in Coral Sea and Hawaiian waters).

- The SEAPODYM web site is implemented www.seapodym.org.

- Archival tag records represent a promising source of observations for the parameterization of modelled fish movement. The analysis conducted last year was fully revised using new forage outputs (6 components instead of 3), enhanced resolution (1/2 deg x 10 days) and additional tag data (all together, 17 archival tags (AT) released in the Coral Sea and 7 Pop-up Satellite Archival Tags (PSAT) deployed on bigeye tuna by SPC in the waters surrounding Papua New Guinea, New Caledonia and Tonga).

- Horizontal movements. Most probable horizontal movements of tagged fish were recalculated using Kalman filter analysis and latitude was corrected so as to minimize the discrepancies between predicted surface temperature and temperatures recorded by archival tags in the upper 20 meters. There was a large amount of variability in dispersion, from apparent residency (17 nm in 109 days for one tuna tagged near New Caledonia) to quick movement (208 nm in 13 days for another one). Eastward migration towards New Caledonian waters at the same period of the year (Oct–Apr) by two individuals and cyclical movement over the year with a similar migration route in 2 consecutive years by one individual were confirmed. Outputs from SEAPODYM suggest that this migration corresponds to a period of seasonal warming and peak biomass of epipelagic and migrant mesopelagic forage.

- Vertical movements. Bigeye tunas exhibited two main types of vertical behavior: the 'classic' W-shaped type with typical depths of 300-500 m during the day and 0-200 m during the night (74 % of total time), and the 'mixed' type with only short dives under 200 m during the day (24 % of total time). The analyses using GAMs show that average depth during the day was positively related to estimated forage biomass in the deep layer (>400m) and negatively related to estimated forage biomass in the 'intermediate' layer (100-400m). This suggests rather logically that bigeye tunas, classically swimming at depths 100-400 m during the day, would dive deeper as bathypelagic forage biomass increases and mesopelagic biomass decreases. The new PSAT archival tag records from New Caledonia and Tonga areas confirm the seasonal trend previously observed in the vertical behavior during the day. A higher proportion of daytime was spent in surface waters during Aug-Nov by nearly all bigeye tuna tagged in the Coral Sea. This shift in vertical behavior would correspond to the period of maximum increase in day length, warming of the surface layer, drop in primary production after a peak in July, and peak in forage biomass in the surface layer. These results are coherent with some observations, e.g. aggregations of bigeye tunas observed in surface waters of this area during the spring months in association with spawning concentrations of 'mesopelagic migrant' lantern fish *Diaphus sp*. It is however difficult to distinguish the roles of feeding and reproduction in the seasonal shift in vertical behavior during the day and the night.

- Development of the bigeye IBM has been cancelled due to unexpected time consuming tasks in the tag analyses.

- Tag records were used for the parameterization of the relation between optimal mean temperature and age in SEAPODYM. Individual tracks were compared to maps of predicted habitat and to vectorial fields of predicted horizontal movements in SEAPODYM. On a monthly scale, a general coherence was observed: NW Coral Sea appeared as a favorable habitat almost all year round and the eastward migration route observed in the individual tracks matched in space and time with a 'corridor' of favorable habitat developing seasonally in the waters between Australia and New Caledonia.

- Idem 5

- Several papers are in final phase of preparation. They describe the changes in the model SEAPODYM and the results from the tagging data analysis.
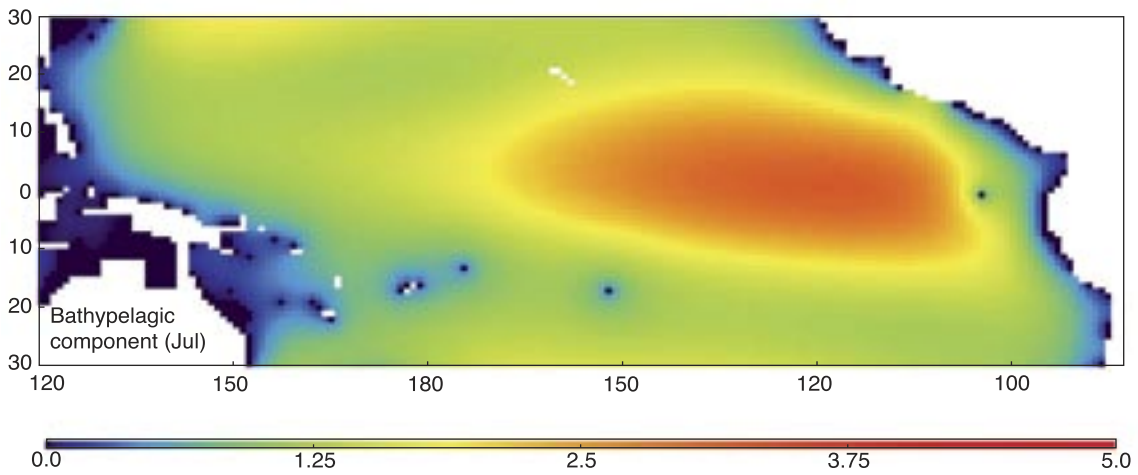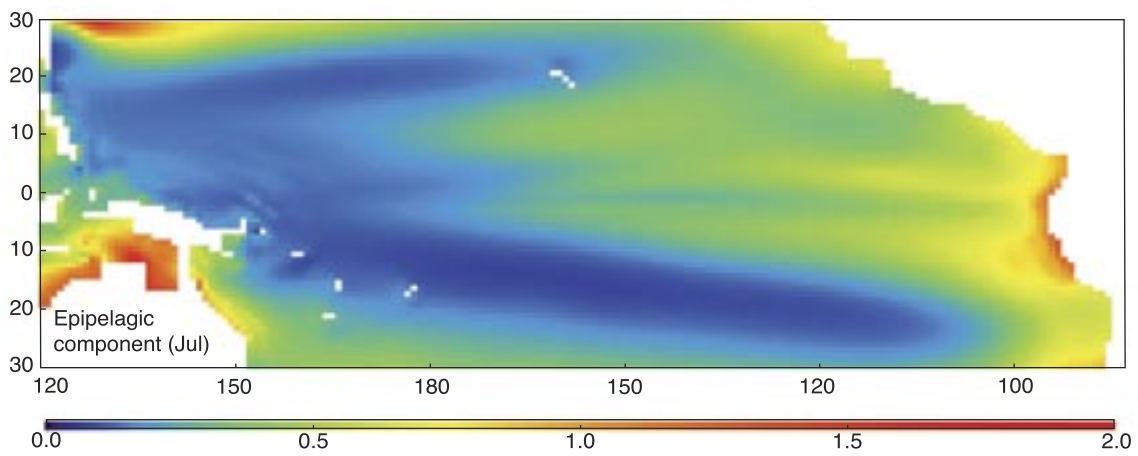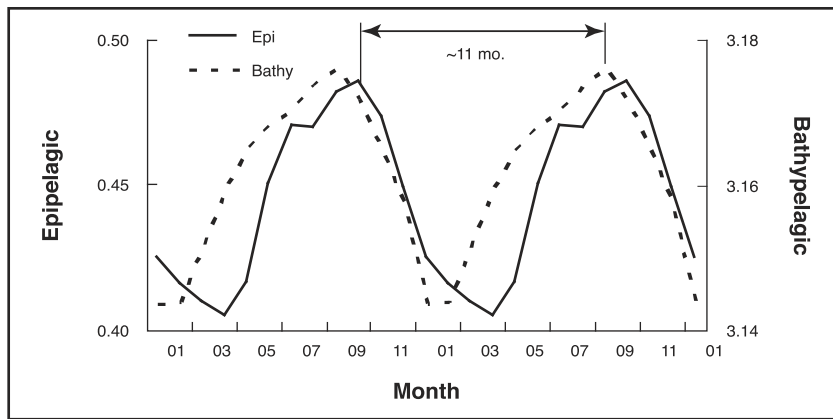
Seasonal cycle and spatio-temporal shifts of mid-trophic (forage) components simulated with SEAPODYM. Due to different temperature habitat, turn-over rates of mid-trophic populations are different. The biomass time series of epipelagic and bathypelagic components (average in the box 5N-5S; 120W-100W) indicates a lag of about 11 months between peaks of the two series. This time lag and the different physical forcing (currents) lead to very different spatial distribution as illustrated for a climatological mean in July for these two components (from Lehodey et al., in prep)
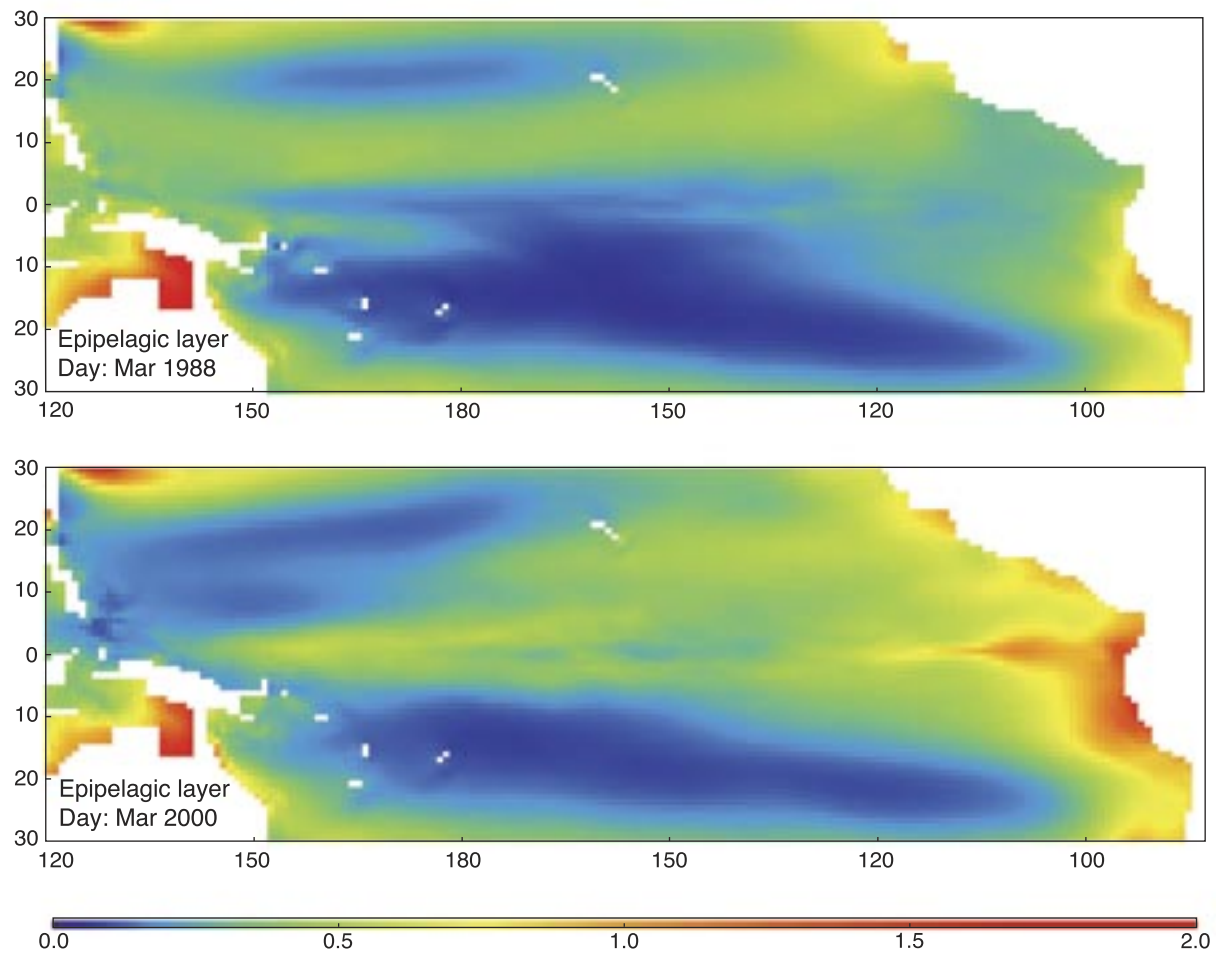
Interannual variability of mid-trophic (forage) components simulated with SEAPODYM. The ENSO impact is shown with the distribution of forage biomass in the epipelagic layer during the day in March 1998 in the final stage of the 1997-98 El Niño event and at the end of the following La Niña event in March 2000 (from Lehodey et al., in prep).

Additional activities associated to this project. The code of SEAPODYM was modified to simplify the prey-predator coupling, to improve the description of movement, to increase the speed of computation and to record the time spent in each layer according to the species, age group (juvenile, young adult), date and region, allowing comparison between prediction and observation from archival tagging or fishing data.

A new key activity is the development of a version of the model with a statistical optimization approach, hereinafter called Seapodym-APE (Adjoint-based Parameter Estimation). Optimal parameterization was tested with an application to skipjack tuna. Derivation of adjoint code was accomplished with help of AUTODIF library (automatic differentiation) functions, although finally it was encoded explicitly in order to avoid huge memory capacity required by automatic functions. Currently, Seapodym-APE includes forward and adjoint code for top predator model only, without coupling between tuna and its forage. Instead forage is being used as input data only. Parameter estimation procedure in Seapodym_APE is based on maximal likelihood technique. Likelihood components are based on catch or CPUE estimated as well as relative length frequencies data. Different types of likelihood functions can be considered depending on data distributions such as log-normal, Poisson, negative binomial, or zero-inflated negative binomial. Experiments on parameter estimation showed that predictions can be significantly improved. However, there are still low correlations between EPO fisheries observed and predicted data. The possible reasons are static vertical structure of environmental data, uncoupled dynamics of forage populations (variability in tuna population dynamics doesn't influence mid-trophic level), many zeros in EPO fishing data.

Modeling Longline Effort Dynamics and Protected Species Interaction

P.I.: PingSun Leung [Naresh Pradhan, Sam Pooley]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The general aim of the proposed study is to refine and extend the existing fleet dynamic model, and the specific objectives and tasks are as follows:

• Extend the longline trip level time-series data set to 2002.
• Re-estimate the technical and economic interrelationships among different species landed and the entry/stay/exit behavior.
• Estimate the catch-effort relationships for each species and for each fleet.
• Analyze the factors, rate, and degree of protected species interaction (e.g., turtles, and seabirds) with longline fishing activities.
• The information generated above will be incorporated into the existing fleet dynamic model in maximizing fishery welfare and fishing effort considering broader implications on protected species and stock conditions.

Progress During FY 2006

The following summarizes the major activities.

• Modification and improvement of the existing fleet effort dynamic model in maximizing fishery welfare by incorporating protected species, seasonal and spatial features in the longline fishery has been completed and an abstract of the work (submitted to Applied Economics) is reproduced below.

Accounting for endangered and protected sea turtle interactions with the pelagic longline fishery by the fishery management has become an important policy goal recently. A multi-objective programming model for Hawaii's longline fishery that incorporated sea turtle interactions (Pradhan and Leung, in press) has been extended with spatial and seasonal dimensions. As a result, the synergetic effect of these added features indicate that there exists better economic and environmental efficiency gains in terms of higher profit and reduced turtle interactions compared to the base case and without these added dimensions by reconfiguring fishing efforts across space and seasons. There also exists a trade-off between fleet-wide profit and turtle interactions. The current fishery policy related to sea turtle interactions disallows capturing all the potential efficiency gain, as the number of turtles allowed to get interacted severely limits swordfish-targeted longline fishing that uses conventional technologies. Restricting longline fishery to operate sub-optimally has average per turtle shadow value of $15,957 and $60,908 in terms of lost profit and revenue, respectively. Adaptation to 'turtle-friendly' fishing technologies is among the many strategies that would allow for higher optimal fishing efforts and also leading to higher overall welfare and towards more responsible fishery.

• A distance function approach has been employed to model sea turtle interaction as an undesirable output in Hawaii's longline fishery. This approach provides a method of calculating temporal and trip-specific cost of sea turtle bycatch reduction without assuming any policy intervention. Such information can be useful in analyzing tradeoffs between number of incidental take of sea turtles and the marginal cost of sea turtle bycatch. The results are summarized in a paper submitted to the Journal of Environmental Management (under revision) and the abstract of the paper is reproduced below:

Interactions with sea turtles have occurred at an alarming rate in swordfish longlining in Hawaii in recent years and various regulations have been put forward to protect sea turtles. In order to understand the cost of reducing sea turtle interactions, methods have been developed to derive the shadow price of sea turtle bycatch based on fisher's welfare loss from a specific regulation. This paper illustrates an alternative method of calculating temporal and trip-specific cost of sea turtle bycatch reduction. The advantages of this method lie in the computation of shadow price without assuming specific regulation implementation and its relatively

modest data requirement. A parametric output distance function is used to simultaneously model desirable and undesirable catches. Using the duality argument, the revenue-related shadow price of sea turtle bycatch can be derived from the estimated distance function. Average shadow price of sea turtle bycatch for the period 1991-1999 is estimated to be US $30,873 in 1991 dollars. Average shadow price of sea turtle bycatch by trip characteristics, such as fishing year, trip type and location are also estimated. Such information can be useful for policy makers to analyze tradeoffs and make appropriate policy decisions.

- Two presentations reporting the results of (a) economic linkage impacts of Hawaii's longline fishing regulations and (b) incorporating sea turtle interactions in a multi-objective programming model with seasonal and spatial dimensions for Hawaii longline fishery have been made at the November PFRP PI meeting.

- Four journal articles from the current project have been published/in press and another two are under peer review.

Modeling the Eco-Physiology of Pelagic Fishes and Sharks with Archival and Pop-up Satellite Archival Tags (PSATs)

P.I.: John Sibert [Michael Musyl, Christina Larsen, Hans Malte, Richard Brill]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

- To serve society's needs for weather and water information

Purpose of the Project

We propose to use available data from archival and PSAT tags to develop IBMs (individual based models) to describe the eco-physiology of different species of large pelagic fishes and sharks. This project will complement data already collected on a number of pelagic species and will be linked to existing PFRP projects by Musyl, Brill, and Moyes. Thus the study will be a collaboration between the University of Hawaii/JIMAR/ PFRP, VIMS/ National Marine Fisheries Service, and the Dept. of Zoophysiology, University of Aarhus, Denmark. Our ultimate goal is to develop model(s), which will be applicable to many different pelagic fish and shark species. Using these models we can evaluate the possible importance of specific oceanographic parameters in an unbiased fashion, which will allow for intra- and inter-species comparison. A second purpose of this study is to explore failure (or conversely success) scenarios in pop-up satellite archival tags (PSATs) attached to pelagic fish, sharks and turtles. Specifically, this aspect of the study is designed to look for explanatory variables in the context of PSAT retention rates, percentage retrieved satellite data (i.e. depth, temperature, geolocations), and tag failure. By examining several factors and information about PSATs attached to vastly different pelagic species, it is anticipated that certain patterns/commonalties may emerge to help improve our understanding of attachment methodologies, selection of target species and experimental design. Lastly, information derived from this study will allow an unprecedented and critical appraisal of the overall efficacy of the technology.
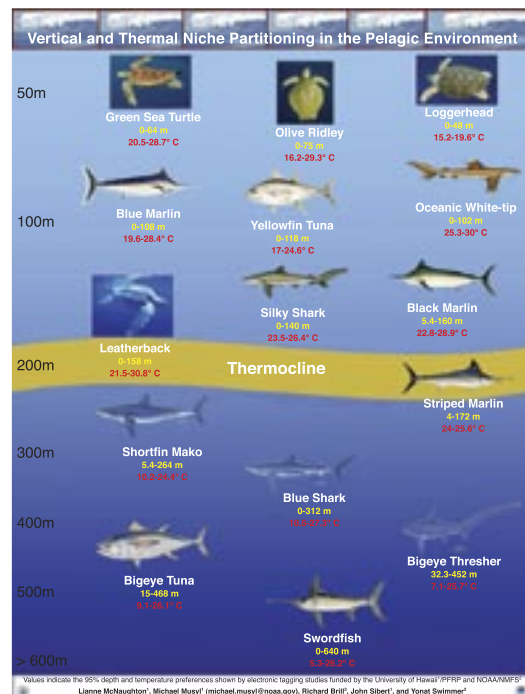
Vertical Niche Partitioning in the Pelagic Environment

Animals located at depth range midpoints, with values giving 35% depth and temperature ranges, as indicated by electron tagging studies funded by the University of Hawaii[1]/PFRP & NOAA/NMFS[2].
Lianne McNaughton[1], Michael Musyl[1] (michael.musyl@noaa.gov), Richard Brill[2], John Sibert[1], & Yonat Swimmer[2]
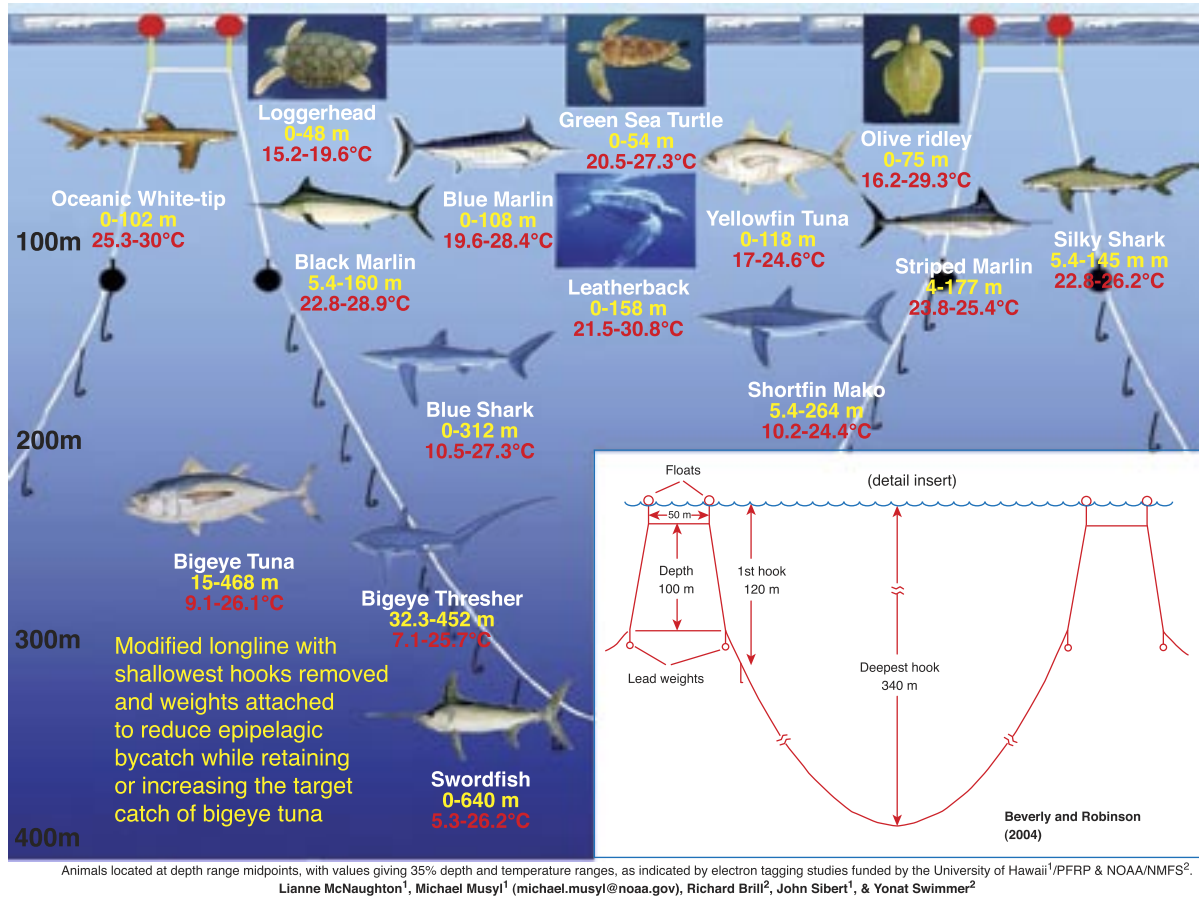
Using Animal Behavior to Reduce Bycatch

Progress During FY 2006

At present, the database contains information from >660 tags across 18 pelagic taxa (including 3 marine turtle species). Preliminary results suggest tags have an overall reporting rate of ca. 78% but PSATs attached to certain species (e.g. swordfish, bigeye thresher shark) have lower reporting rates. Non-reporting tags is not synonymous with mortality. It is anticipated that eventually this study will examine information from over 1000 PSATs. In the future, these data will be publicly posted on the PFRP web site.

Development of a database (and associated tools) to examine/correlate movement patterns of PSAT tagged animals with various oceanographic parameters on temporal and spatial scales (i.e. both horizontal and vertical) is near completion. An abstract recently presented by R. Michael Laurs, David Foley, and Michael Musyl describes this work (Integrated Ocean Observation Systems [IOOS] for Managing Global and Regional Ecosystems, US/EU-Baltic International Symposium, May 23-25, Klaipeda, Lithuania; entitled, "Identification of Large Pelagic Marine Fish Habitats and Habitat Utilization Using 'Pop-Up' Satellite Archival Tag and Oceanic Satellite Remote Sensing Technologies and 'Soda' Simple Ocean Data Simulation Model Analyses.").

"Large pelagic fishes (tuna, billfish, and sharks) are being tagged with 'pop-up' satellite archive electronic sensors (PSAT), which measure and log detailed data on the swimming environment of the fish, as well as light data, which are used to estimate the geographic locations of the fish. At predetermined periods the sensors are programmed to 'pop-off' the fish, float to the sea surface, and transmit the data collected to Argos satellites, which relay the data to ground stations on earth. Processing of these data provides detailed time-history information on the environment and estimated locations of individual free-swimming fish. The resulting information is then examined in conjunction with ocean measurements and data products derived from various satellite ocean sensors including sea surface temperature, ocean color, and ocean winds, as

well as SODA ocean data assimilation model analyses. The fish habitats are thus defined in the context of surrounding ocean conditions, measured contemporaneously by oceanic satellite remote sensing and derived from outputs from the SODA ocean simulation model. An important aspect of this approach is that it provides the opportunity to identify, and subsequently monitor with satellite remote sensing, ocean features, processes, and properties that may play important roles in determining spatial and temporal variations in marine fish habitats. Data are presented that demonstrate this approach for blue shark, Prionace glauca.*"*

Oceanographic Characterization of the American Samoa Longline Fishing Grounds for Albacore, *Thunnus alalunga*

P.I.: John Sibert [Michael Seki, Jeffrey Polovina]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The American Samoa domestic longline fishery has undergone extraordinary growth, particularly in the fleet composition of large vessels (>20 m in length) that have fueled a fivefold increase in fishing effort and landings from 1999 to 2001. The most intense period of the expansion occurred during 2001, when the total number of hooks set increased tenfold from 860 thousand during 2000 to 8.6 million in 2002. The target species of the longline fleet is albacore tuna, *Thunnus alalunga*, which dominates the catch. Oceanographically there has been little study regarding the pelagic habitat in the American Samoa region. The current research undertakes the task of characterizing the pelagic habitat and fishing grounds occupied by the American Samoa longline fishery through the use of satellite oceanographic remote sensing and in situ shipboard surveys. Coupled with the oceanographic assessment will be fishery information to develop a functional understanding of the spatial and temporal occupation and movement tendencies of large South Pacific albacore and the role of the environment on longline gear performance and catch. These data include albacore depth distribution and gear performance obtained from commercial longlines instrumented with time-depth-temperature recorders (TDRs) and the set level catch information from the American Samoa fishery logbook program.

Progress During FY 2006

Results of the first part of the two-year project to characterize the American Samoa albacore habitat and fishing grounds are being prepared for publication in a peer review journal, to be submitted in FY 2006. The paper will basically describe the findings of the March 2004 oceanographic survey. As the second part of the project, a second oceanographic survey of the American Samoa longline fishing grounds was conducted during February 15 through March 02 aboard the NOAA ship Oscar Elton Sette. Since results from the first part of this project indicate that the eastward flowing, seasonal South Equatorial Counter Current (SECC) has a significant effect on the American Samoa longline fishery performance for albacore tuna, survey activities were designed to investigate the importance of the SECC for the longline fishery, focusing on the high shear boundary regions between the SECC and the westward flowing South Equatorial Current (SEC). During the cruise, dual frequency (38 and 120 kHz) bioacoustic and ADCP (75 kHz) transects were conduced at four study sites to investigate their effects on the distribution and abundance of albacore and their forage, micronekton, in these regions frequented by the longline fleet. In addition to bioacoustic backscatter and in situ currents information, temperature, salinity, dissolved oxygen, and chloropigments were determined via CTD casts and trawl samples collected at depths of high sonic scattering layers. Concurrent with the survey operations, pop-up archival transmitting satellite tags were attached to seven albacore tuna to collect information on habitat characteristics such as preferred temperature and depth ranges of individual fish.

Preliminary results of the surveys seem to indicate that anticyclonic eddies are formed from waters carried by the SECC. The strongest sonic scattering layers, indicating dense aggregations of micronekton, are found between 500 and 900 m deep during the daytime, usually composed of two prominent layers at 500-650 m and 750-900 m, and in the upper 200 m during nighttimes (Fig. 1). However, both layers persist at all times with
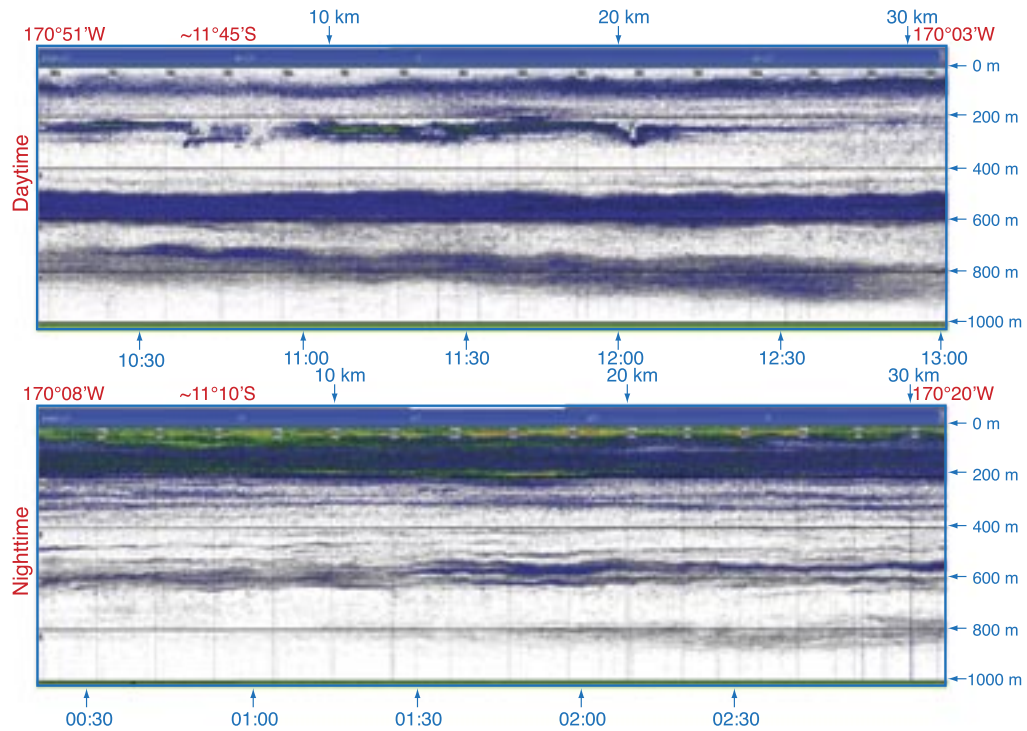
38 kHz echograms showing the typical daytime deep (double) and nighttime shallow scattering layers, with the addition of the persistent thin layer at 200-300 m.
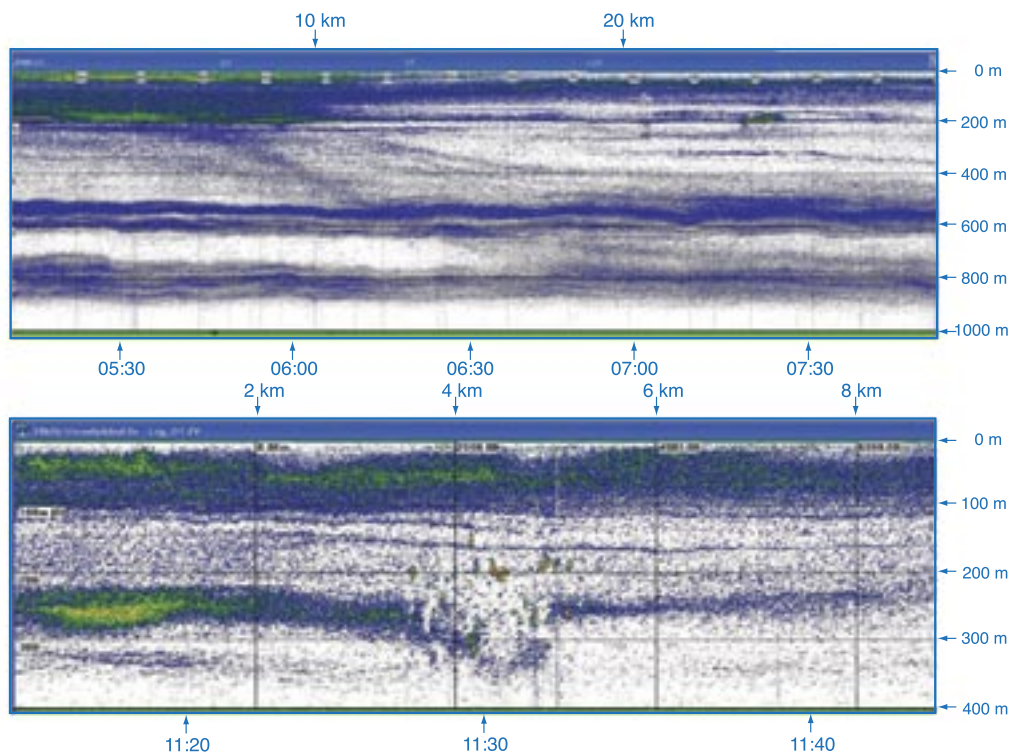
38 kHz echograms showing dawn vertical migration patterns of organisms (upper panel) and nekton apparently feeding on micronekton in the 200-300 m thin scattering layer (lower panel).

another persistent, although thinner, layer at around 200-300 m. Dawn and dusk echograms show that a significant portion of the organisms migrate between the surface and the 750-900 m deep layer (Fig 2a), indicating the possible importance of water characteristics down to 900 m depth. Large aggregations of nekton are prominent throughout the days but rarely observed at nights. Almost exclusively, all nekton aggregations are found between 200 and 300 m below the surface, apparently feeding on the organisms composing the scattering layers at those depths (Fig. 2b). High micronekton biomass seems to be related to SECC water masses but unrelated to high nekton biomass. The effects of water properties on nekton distribution and biomass are not evident from the preliminary results, although the bioacoustics data have not been analyzed in detail. Analysis of the in situ data (ADCP currents, Cobb trawl samples, bioacoustics, and pop-up tag temperature and depth), with the combination of satellite altimetry and log books catch from the longline fleet, has begun and will continue during the rest of FY 2006.

Pelagic Fisheries Research Program: Program Management

P.I.: John Sibert

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

Manage the activities of the PFRP, solicit and implement new research proposals, and promote science-based management of fisheries for highly migratory fisheries in the western Pacific Ocean.

Progress During FY 2006

- *Work closely with the PIFSC to improve budgetary arrangements and coordination of research programming.*
A new "umbrella" proposal was jointly developed with PIFSC to enable the PFRP to more effectively interact with NOAA. A programmatic environmental assessment document was prepared for the umbrella proposal covering all PFRP activities and a draft FONSI was approved.

- *Convene a workshop to identify new research priorities for the PFRP.*
The original PFRP research priorities were established in a 1992 workshop. Most of the topics identified during that workshop were addressed in the first few years of PFRP operations. In the intervening years, management concerns, governance arrangements, and the fisheries themselves have changed drastically. A second workshop to identify new research priorities for the PFRP was convened November 16-18, 2005. Representatives from the Western Pacific Regional Fishery Management Council, NOAA/PIFSC, National Research Institute for Far Seas Fisheries (Japan), Inter-American Tropical Tuna Commission, and Secretariat of the Pacific Community presented views on research priorities around the Pacific. Scientists and resource managers developed lists of research priorities in the four general disciplines: applied economics, ecosystem integration, biology and life history and fishing communities.
The workshop report, "Pacific Ocean Connections: Priorities for pelagic fisheries research in the Twenty-first Century," was used as the basis for the request for proposals. The RFP attracted interest from 59 potential researchers; and after a peer review process, 14 of 28 proposals were selected for funding.

- *Facilitate international collaboration in research on pelagic fisheries.*
The PFRP remains active in international tuna research and management. The PFRP Program Manager and several PFRP scientists were members of the United States Delegation to the first meeting of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in Western and Central Pacific (WCPFC). The PFRP hosted the first meeting Steering Committee of the of the new GLOBEC project, Climate Impacts on Oceanic Top Predators (CLIOTOP).
The successful research proposals in the recent RFP will provide funding for research collaboration in Australia, France, New Caledonia and Papua New Guinea.

- *Education and training*

The PFRP currently supports two graduate research assistants. Brittany Graham, a PhD candidate in the Oceanography Department, continues to be productive member of the pelagic food web project, "Trophic structure and tuna movement in the cold tongue-warm pool pelagic ecosystem of the equatorial Pacific." Peter Ajtai is a new graduate student with the Oceanography Department and is working with PFRP staff. Richard Hall, a Masters candidate in the Geography Department, has completed his tenure with the PFRP, and has submitted a draft dissertation on optimizing marine protected areas for the WCPO tuna purse seine fishery.

Satellite Remote Sensing Research Program

P.I.: Thomas Schroeder [Jeffrey Polovina]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

This project has two related aspects: 1) to use satellite remotely sensed oceanographic data to describe ocean dynamics, particularly features of importance to living marine resources; and 2) to use satellite remotely-sensed data together with data on movement of pelagic animals to define the critical oceanic habitats of these pelagic animals.

Progress During FY 2006

A paper on validation of geolocation methods using pop-up archival transmitter (PAT) and Argos-linked tags attached to whale sharks was completed. This paper has been submitted for publication. Work on analyses of
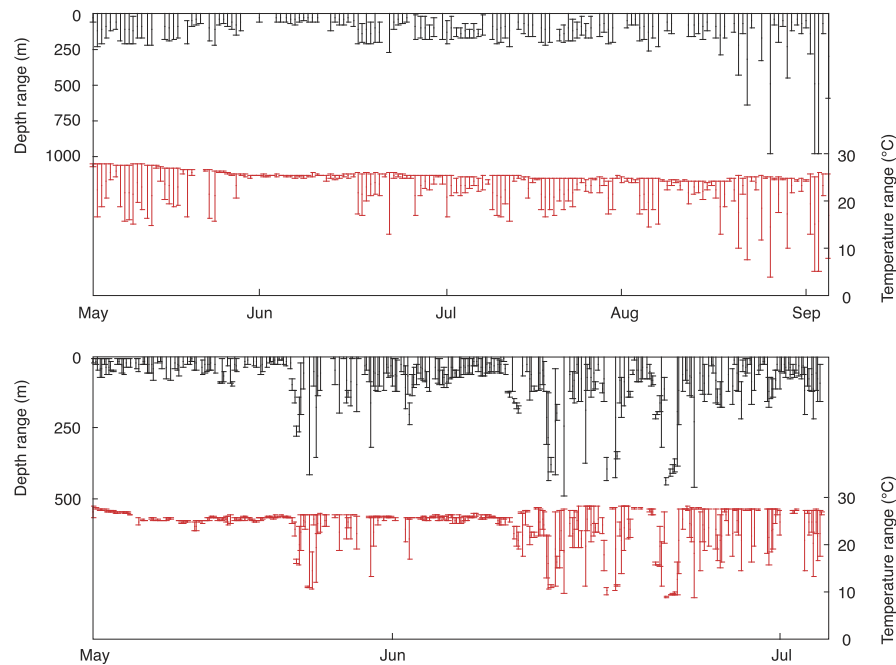
Daily minimum and maximum depth and temperature for 2 whale sharks at Ningaloo Reef in western Australia, derived from electronic tagging. (From Wilson et al. 2006)

electronic tagging data for opah has begun, which should result in a manuscript during 2007. A tagging cruise was conducted around Hawaii resulting in the deployment of 11 electronic tags on various pelagic fishes.

In our 2005 annual report we articulated several planned efforts for this fiscal year: 1) a paper on whale sharks that was in review is now published; 2) a paper on bigeye tuna spatial dynamics that was in preparation has now been submitted for publication; and 3) a planned deployment of additional tags around Hawaii was achieved.

Satellite Remote Sensing Research Related to the West Coast Integrated Ocean Observing System

P.I.: Thomas Schroeder [Franklin Schwing]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Southwest Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- To understand climate variability and change to enhance society's ability to plan and respond
- To serve society's needs for weather and water information
- To support the nation's commerce with information for safe, efficient, and environmentally sound transportation

Purpose of the Project

The purpose of this project is to conduct research and provide satellite data in support of the emerging west coast regional associations of the Integrated Ocean Observing System (IOOS). These efforts are undertaken to 1) improve understanding of marine environmental variability and its impacts on living marine resources, 2) develop improved living marine resource assessment models, and 3) apply satellite remote sensing technology to the improvement of management of economically and ecologically important marine resources.
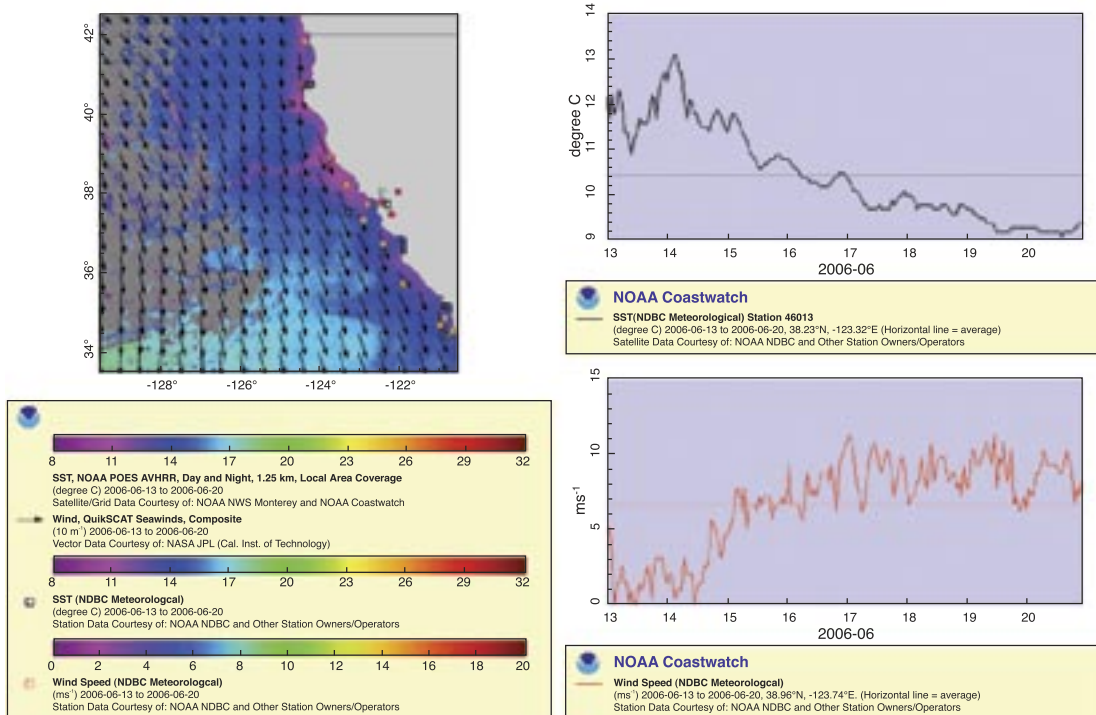
Sample working screen from new CoastWatch Browser featuring overlay of in situ data platforms with complementary satellite data. The program also allows site-by-site extractions of time series.
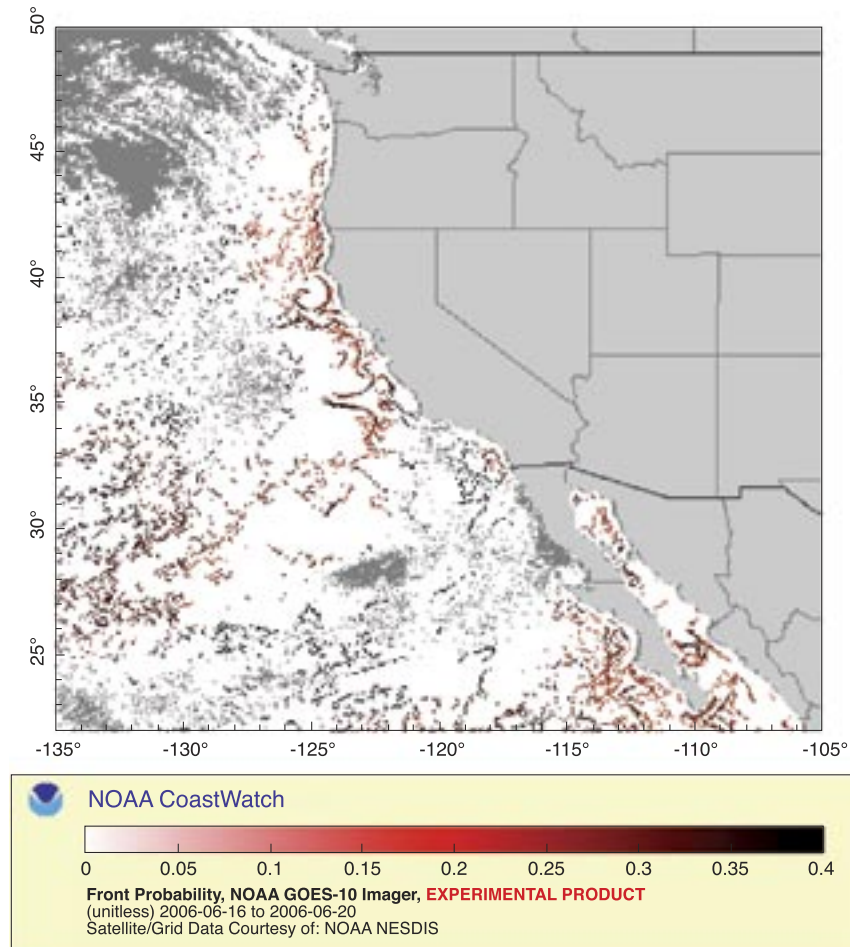
Sample image showing frontal probability index along the West Coast of North America, for a 14-day period in June 2006. Index based on GOES SST data.

Progress During FY 2006

The Satellite Remote Sensing project in FY06 was focused on developing and expanding infrastructure and communication systems for a wide variety of satellite data and products in support of NOAA's mission and the Regional Associations and partners of IOOS. This is in addition to the fundamental goal of supplying oceanographic data sets as the West Coast regional node (WCRN) of the NOAA CoastWatch program.

• *Completed West Coast Browser*

The New CoastWatch Browser has now been released (Figure 1). This browser uses technology that is compliant with IOOS standards, and developed out of a year of intensive programming to add features and incorporate key feedback from data users. New features include the ability to display and extract relevant in situ data sets (e.g., from moorings and drifters) for comparison with the various satellite data products served by the WCRN. It is hoped that the addition of this capability will increase the confidence our users have in the quality of our data. By request from the Director of CIOSS, a South American version of the browser was also released, and is in daily use by scientists in Peru (IMARPE) and Chile http://coastwatch.pfel.noaa.gov/coastwatch/CWBrowserSA.jsp

• *Release of Frontal Probability Index*

The frontal probability index developed from the GOES SST data stream by Tim Mavor (ORAD) is now being served on the WCRN data browsers as an experimental product (Figure 2). Following a successful evaluation by researchers at CIOSS and UC-Santa Cruz, the WCRN submitted documents to NESDIS requesting that the product be made operational. We have received confirmation of receipt of this request and are awaiting action by

the relevant NESDIS committee. The GOES frontal product continues to be quite popular with CoastWatch data users in North and South America.

• *Integrating Satellite Data into Coastal Management*

JIMAR personnel collaborated on a project with NOAA's Monterey Bay National Marine Sanctuary (NMS) to use satellite SST data to characterize the oceanic features in the vicinity of the Cordell Bank NMS, the Gulf of Farallones NMS, and the Monterey Bay NMS. There are strong variations in the distribution of upwelling regions, offshore intrusions of warm water and frontal zones, all of which impact the regional ecosystem. Consequentially, using satellite data to better document the geographic extent of these phenomena can be useful in determining the boundaries of marine reserves designed to protect marine LMRs.

Sociological Baseline of Hawaii Longline Industry

P.I.: John Sibert [Stewart Allen]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The Hawaii-based longline fishing industry has been heavily regulated with little analysis of the socio-cultural impacts of those regulations and management. The ethnically diverse makeup of longline industry participants in Hawaii and the dynamic nature of the industry highlight the need for primary data on contemporary sociocultural characteristics. Project researchers are addressing this problem by compiling a comprehensive social profile of the longline fishing industry of Hawaii; and providing social profile information to decision-makers on regulatory impacts and implementation strategies.

JIMAR researcher Amy Gough enjoys the Honolulu sunset with Filipino crew members.

Progress During FY 2006

Interviews with 234 longline fishermen, including owners, captains, and crew, were formally completed in FY 2004-2005. The research team continued to make visits to the pier areas until December 2005 to maintain contact with the fishermen and learn about new developments. These visits were documented in additional project narratives and are being used to help interpret interview results.

The main emphasis has been on analyzing data and writing a series of reports. Currently, reports have been drafted on: impacts of the swordfish closure (and re-opening) on Vietnamese-American fishermen; fishermen's perceptions of and experiences with observers and the observer

JIMAR interpreter/community liaison Daniel Isidro (pictured holding hooks) with Filipino crew members.
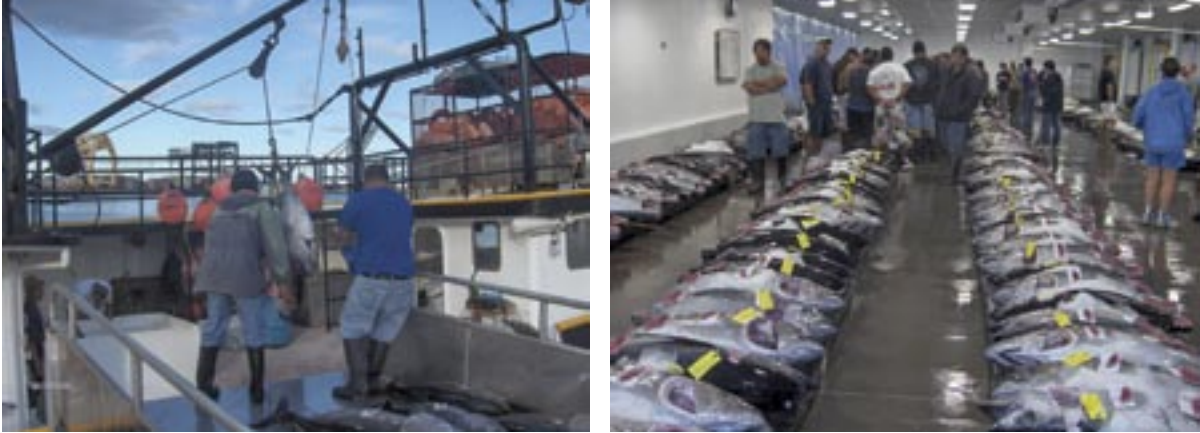
(above left) Landings of Hawaii Longline Fishery at an Oahu Pier. (right) Oahu's Fish Auction Market, Hawaii.

program; fishermen's perceptions of National Marine Fisheries Service regulations and management; and the experiences of Filipino crew members in the Hawaii-based longline fleet. These papers are all in various stages of review in the PIFSC review process.

Spatial Modeling of the Tradeoff between Sea Turtle Take Reduction and Economic Returns to the Hawaii Longline Fishery

P.I.: John Sibert [Minling Pan, Shichao Li]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

Construct a bio-economic modeling of multiple time-area closures to evaluate the tradeoff between sea turtle take reduction and economic returns to the Hawaii-based longline fishery. This bio-economic modeling of multiple time-area closures can be applied to protecting other endangered species and to managing bigeye / yellowfin tuna catch for the Hawaii longline fishery.

Progress During FY 2006

• Designed and programmed flexible and multiple time-area closures to allow the model to assess closures that are combinations of different areas (by one degree of latitude and/or longitude) and seasons (1 to 12 months) by specific set types;

• Applied regression statistics to identify the variables that significantly contribute to variable costs of longline fishing. Along with set type (deep set or shallow set), number of sets, length of vessels, and average distance of sets to ports significantly affect variable costs of each trip.

• Built a cost function into the model to measure the changes of net revenue to the fisheries under different closure options.

Survivorship, Migrations, and Diving Patterns of Sea Turtles Released from Commercial Longline Fishing Gear, Determined with Pop-Up Satellite Archival Transmitters

P.I.: John Sibert [Yonat Swimmer, Mike Musyl, Lianne McNaughton, Richard Brill]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

The objectives of this project are two-fold: to provide estimates of delayed mortality and morbidity in sea turtles following interactions with longline fishing gear; and to compare the movements and behaviors of sea turtles caught and released from longline gear to free-swimming controls. To do this, we've deployed pop-up satellite archival tags (PSATs) on longline-caught and free-swimming hard-shelled turtles in the Eastern Tropical Pacific, the North Pacific, and the South Atlantic Oceans.

Progress During FY 2006

Since July 2005, we have deployed additional PSATs on 9 loggerhead turtles caught and released from longline fishing boats in the Hawaii swordfish fishery in the North Pacific Ocean and on 4 loggerhead turtles released from Brazilian longline vessels in the Southwest Atlantic Ocean. We have trained ca. 40 Brazilian and Hawaii-based at-sea observers in attachment procedures, and also conducted workshops with observers and fishermen on the use of dehooking equipment to encourage use of best practices for turtle release. We have also begun to deploy PTTs on turtles in Brazil.

The number of turtles we've had access to for such tagging has been somewhat out of our control due to extensive fisheries measures to reduce

Movements of 3 loggerhead sea turtles after their release from longline fishing gear in the Southwest Atlantic Ocean. PSATs attached by Brazilian fisheries observers. Turtles' most probable tracks were determined using a KFSST model in collaboration with Dr. Anders Nielsen.

sea turtle bycatch. Therefore, we deployed tags on as many turtles as possible before the Hawaii swordfish fishery was shut down in March, and also worked with Brazilian colleagues to get tags on turtles. We have had problems with tag retention and with the amount of useful data obtained from the tags.

Sustainable Fisheries Initiative

P.I.: Thomas Schroeder [Alvin Katekaru, John Kelly, Charles Karnella]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Regional Office

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of the Sustainable Fisheries Initiative (SFI) is to foster sustained optimal use of fishery resources and to provide maximum protection to marine endangered and threatened species in the Pacific islands region. Project activities are authorized under the Magnuson-Stevens Fishery Conservation and Management Act (Magneson-Stevens Act) and other applicable laws such as the Endangered Species Act, Marine Mammal Protection Act, National Environmental Policy Act, and are based on the best scientific information available. SFI involves the collection and analyses of scientific data, including socio-economic information, and as appropriate, the use of these data for fisheries management and conservation actions. SFI also evaluates biological, environmental, and economic issues such as, protected species interaction mitigation, including fishermen education and data collection/monitoring in domestic and international fisheries. The desired outcome is to increase food supply, enhance the economy, maintain and foster island culture, and maximize commercial and recreational fishing opportunities in the U.S. flag island areas in the Pacific Ocean. SFI also has projects in Papua New Guinea and the Federated States of Micronesia.

Sustainable Fisheries and International Program

Sustainable Fisheries Division (SFD), working closely with the PIRO Observer Program, provides outreach and education for U.S. fishermen from commercial longline and bottomfish vessels. The purpose is to provide fishermen, including new observers, with information and instruction on protected species mitigation and deterrent methods involving sea turtles, seabirds, and marine mammals. The International Program engages in turtle conservation outreach and education activities in the Federated States of Micronesia and Papua New Guinea. The program also collects tissue samples of turtles and life history information for analyses by NOAA fisheries scientists.

Observer Program

The Observer program provides high quality data on protected species interactions (sea turtles, marine mammals and sea birds), catch composition, fishing effort, and selected fisheries research projects from commercial longline and bottomfish vessels based in Hawaii and on longline fishing vessels based in Pago Pago American Samoa. The data are collected at sea by fisheries observers. The debriefing/resource management staff/data surveyors primary purpose is to train observers, and ensure the quality and integrity of data collected by the observers thorough debriefing observers and data editing; provide technical expertise to the Forum Fisheries Agency/South Pacific Communities (FFA/SPC) observer trainings by working with observer trainees in species identification for fish and cetaceans; provide technical expertise to FFA/SPC regarding observer debriefing and data analysis procedures; participation in international meetings, participate in the International Observer Workshop, present at technical meetings and workshops, review and comment on fisheries regulations.

Progress During FY 2006

For 2006 the Observer Program is maintaining a 22.1% coverage rate for the Deep Set Fishery (Tuna); 20% coverage rate for the bottomfish fishery and a seven percent (7%) coverage rate for the American Samoa fishery. During 2005 the program maintained an observer coverage rate of 26.1% for the Deep Set Fishery (Tuna) which is 479 observed trips and 7,099 sea days; 100% observer coverage for the Shallow Set Fishery (Swordfish) which is 106 observed trips and 3,294 sea days and 22.1% observer coverage for the bottomfish fishery which is 13 trips and 233 sea days. The program realized a significant increase of observed trips during 2006.

The program continues to provide support to the Forum Fisheries Agency/South Pacific Communities (FFA/SPC) by sending observer program staff to their observer trainings to provide training in fish species identification and cetacean species identification, techniques in debriefing observers, collection procedures and protocols and dehooking procedures. The program continues to work with the office of Sustainable fisheries by providing staff

to help with the Protected Species Workshops both in Hawaii and American Samoa. The Program supports the Science center with the Northwest Hawaiian Islands lobster research effort.

The program is continuing to provide technical expertise to the Federated States of Micronesia, The Republic of the Marshall Islands, the Republic of Palau, Tonga, Fiji, Papua New Guinea the Cook Islands and other Pacific Island states. Thus far during 2006 the program has provided support for the Marshall Islands, the Republic of Palau, the Federated States of Micronesia and Papua New Guinea.

Sustainable Fisheries and International Fisheries Program

SFD collaborated with the Observer Program in training 91 new fisheries observers in sea turtle dehooking methods; trained 178 fishing vessel operators and crew members from the Hawaii longline fleet in sea turtle dehooking methods; developed and produced two NOAA public announcements for a local television station on coral reef restoration and how seafood goes from the ocean to one's dinner plate; processed and issued shallow-set certificates for the Hawaii longline swordfish fishery, the data from which are being analyzed to determine the effectiveness of the certificate program; implemented a national seafood processor survey for Pacific islands region; processed and renewed Hawaii longline and Northwestern Hawaiian Islands bottomfish limited entry permits from which profile information is used for monitoring these fisheries; restructured the permit database to allow for effective information availability to constituents; certified 88 American Samoa longline permit holders and 199 Hawaii longline permit holders to meet protected species workshop requirements of western Pacific pelagic fishery management plan; prepared fishery conservation and management measures for seabird protection; marine turtle conservation and longline fishery limited entry program.

The International Fisheries Program (IFP) continued its sea turtle projects in Papua New Guinea (PNG) and the Marshall Islands. Under The Papua New Guinea Sea Turtle Interaction Mitigation and Outreach Program Phase II a prawn trawl expert was contracted to assist in the training of fishermen in the manufacture and deployment of Turtle Excluder Devices (TEDs). The trawl expert experienced communication difficulties in obtaining fishing gear specifications from fishing companies, causing project delays. Difficulties were also encountered in identifying a machine shop that had the capability and raw materials for manufacturing metal grids, integral parts of TEDs. Also, because of rising fuel costs most vessels participating in the project had to cease fishing and contract with the trawl expert had to be terminated. Another contract employing a fisheries expert resulted in successful phase II training of PNG fisheries observers. The primary objective of this contract was to give PNG National Fisheries Authority (NFA) staff references, tools and knowledge to conduct fisheries observer training. The fisheries expert trained observers with PNG National Fisheries staff present. Subsequently, under the fisheries expert supervision, staff successfully trained a subsequent group of observers.

The Marshall Islands Outer Island Sea Turtle Genetic Sampling and Data Collection project involved the Women United in the Marshall Islands (WUTMI). WUTMI enabled eight data collectors from the atolls of Ailuk, Likiep, Wotje, and Majuro to collect 127 turtle skin samples for analyses by NOAA fisheries scientists. Results of these analyses should establish a haplotype for turtles nesting on Marshall Islands beaches and provide insight into the natal beaches of juvenile turtles captured by fishermen in the nearshore territorial waters. This project should provide a better understanding of turtle migrations and areas of potential interaction with fisheries. WUTMI data collectors also obtained information to characterize marine turtle aggregations in the Marshall Islands by taking measurements and photographs of turtles, and writing reports on turtle utilization for sustenance and cultural practices. A final report on the project is being prepared.

Fisheries Oceanography: Swordfish Research

P.I.: Thomas Schroeder [Karen Sender]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The purpose of this project is to conduct research on the population assessment of North Pacific swordfish and other highly migratory species. This project also supports fulfillment of U.S. obligations for the Interim-Scientific

Committee for Research on Tuna and Tuna-like Species in the North Pacific. Current specific tasks include developing data management methodologies to ensure accurate, complete, and well-documented data to support this research.

Progress During FY 2006

In the FY2005 annual report, three primary goals were described for FY2006: 1) continue to develop InPort, including: a) creating a high level inventory of all National Marine Fisheries Service's fisheries-dependent data holdings and a detailed inventory and documentation of fisheries permit systems, and b) enhancing metadata importing and exporting tools, developing additional metadata modules, and enhancing user and librarian support tools; 2) continue to develop the Longline Observer Data System (LODS), including further integration of economic data and enhanced reporting tools; and 3) packaging and making available to Pacific Islands Fisheries Science Center (PIFSC) and other fisheries offices some additional data management tools. Progress toward these goals is described below.

1. Fisheries Information Systems InPort v. 2 Development

Project Objective: To provide National Marine Fisheries Service's Fisheries Information Systems with a centralized repository for managing and accessing information—metadata—about fisheries data. Grant funds solely for contractor support.

2006 Status and Accomplishments
- InPort acceptance. In December 2005, the InPort Metadata Catalog system passed acceptance testing by National Marine Fisheries Service's Office of Science and Technology. This system is now officially accepted by FIS. This system can be accessed at https://ias.pifsc.noaa.gov/inport where information about InPort functions and use are provided in the InPort User Guide.

- Fisheries-dependant metadata gathering. Work has begun to catalog and document PIFSC's and other fisheries partners' data assets. There are currently eight metadata libraries registered in InPort.

- Detailed inventory and documentation of fisheries permits systems. This has taken place through the FIS National Permits Systems team and they are beginning to enter that information into InPort.

- InPort importing/exporting tools. Tools for importing data dictionary information from Oracle databases have been developed, tested, and put into production. Tools for exporting metadata out of InPort are incomplete because we are waiting for standards clarification from NOAA, but current plans are to follow the Geospatial One-Stop model.

- Additional InPort enhancements and support tools. Quick response to user reports of bugs and requests for system enhancements continue. Application help text and guides are managed through an online database. Development of the InPort User Guide, including tutorials, was accomplished. Reports were developed to assist metadata librarians in managing their users and catalog items.

2. Longline Observer Data System (LODS)

Project Objective: Continue the maintenance and enhancement of LODS. Grant funds solely for contractor support.

2006 Status and Accomplishments
- Integration of economic data. Modified LODS to allow input and management of economic data (Trip Costs): this enhancement has been developed and tested.

- Enhanced reporting tools. Developed additional data quality and quality assurance reports that provide statistics on data processing performance, which allowed improvements to workflow and resulted in more efficient and timely data processing.

- Additional development. New monitoring requirements for the swordfish longline fishery and the planned adoption of LODS by the new American Samoa Observer Project are being managed through the continued development in FY2006 of the Data System Change Request (DSCR) process that was initially developed in FY2005. The DSCR allows for complete tracking of change requests and eventual system modifications.

The DSCR has also resulted in more consensus-driven decision making on LODS development and modifications.

3. Additional 2006 Accomplishments

- The LODS and InPort projects have resulted in the development of data management tools, best practices, and system architecture that benefit each project and will be additionally available for improving other fisheries data systems at PIFSC.
- The web-enabled data access tool, Data Trawler, has been developed and is currently being tested by users. This tool will provide a user a list of data sets (to which the user has been granted access) and then allow the user to select, view, and optionally download those data while maintaining a history of the user's data access activity.
- The creation of application and database environments for development, testing, training, and production will help ensure uninterrupted production and smooth implementation of fully tested system revisions.
- Additional database management tools for auditing data changes (Data History) in current and new data systems will assist in data quality assurance and control.

Trophic Ecology and Structure-Associated Aggregation Behavior in Tuna

P.I.: Kim Holland

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

Purpose of the Project

To investigate the behavior, aggregation dynamics and feeding habits of tuna when they are found in association with anchored buoys such as the fish aggregating device (FAD) network that is deployed around the Main Hawaiian Islands (MHI). Recent emphasis has been shifted to characterize the nature of these aggregations when they are associated with privately deployed buoys (pFADs).

Progress During FY 2006

Analysis of inter-FAD movement data continued and resulted in the submission of a manuscript that is in the process of second review. Analysis (both gut contents and stable isotope techniques) of the feeding behavior of FAD-associated tunas resulted in publication of these data (Graham et al 2006). Acquisition of sample storage equipment and personnel training for data collection of pFAD-associated tuna was completed but activity was temporarily terminated due to an almost complete failure the 2005/06 pFAD fishing season.

Trophic Structure and Tuna Movement in the Cold Tongue-Warm Pool Pelagic Ecosystem of the Equatorial Pacific

P.I.: John Sibert [Valerie Allain, Robert Olson, Felipe Galván-Magaña, Brian Popp]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

Previous modeling suggests that tuna productivity in the western and central Pacific Ocean is tied to upwelling along the equator in the central and eastern Pacific. This project proposes to test this hypothesis by combining diet

analysis, stable isotopic analyses, and food-web modeling to study trophic-level variation and tuna movements in the equatorial Pacific. Our hypothesis predicts that tunas that reside near equatorial upwelling regions feed at relatively low trophic levels. Opposite trends are expected in equatorial regions with little upwelling, such as the warm pool of the western Pacific, where tunas are expected to feed at higher trophic levels and move extensively, searching for less-abundant prey. The main objectives of the project are to define the trophic structure, establish an isotope-derived biogeography, and characterize large-scale tuna movements in the pelagic western, central, and eastern tropical Pacific. Results of this study should help define ecosystem linkages leading to tuna production and the effect of climate variability on the systems. This information is important for both fisheries production and ecosystem modeling of the equatorial Pacific Ocean.

Progress During FY 2006

Sampling and Stomach Content Analysis

In the western and central Pacific, since the beginning of the project, 90 sampling trips on tuna fishing vessels have been completed. Of the 3140 stomachs collected so far from about 66 species, 2531 have been examined in the laboratory. Samples from two new areas, the EEZs of Wallis & Futuna and Fiji, have been collected.

In the eastern Pacific, fauna from 272 sets made during 64 trips on tuna purse-seine fishing vessels have been sampled since the beginning of the project. Samples of stomachs, muscle, and liver tissues have been collected from more than 10,700 specimens of about 47 taxa. The majority of the stomach samples have been partially or completely analyzed in the laboratory. The diet data from 53 trips are being analyzed by two students at CICIMAR, Mexico, and for 11 trips by students in Manta, Ecuador (all supervised by F. Galván).

Stable Isotope and Mercury Analyses

Since the beginning of the project, ~2800 samples have been isotopically analyzed; the $\delta^{15}N$ and $\delta^{13}C$ of ~1700 samples were determined during FY2006. Our isotope dataset for the equatorial Pacific shows spatially-explicit patterns of trophic dynamics for tropical tunas in the pelagic ecosystem (Graham et al. 2006b). If a predator migrated extensively throughout these regions, then little geographical isotopic variation would be expected because regional $\delta^{15}N$ differences would be integrated over space and time. $\delta^{15}N$ spatial variability is high (12‰) for the tropical tunas, implying these species exhibit a surprisingly high level of regional residency. Species-specific $\delta^{15}N$ maps are a powerful tool to examine differences in trophic ecology and migration between species (see Graham et al. 2006b).

Stable isotope analysis of mesozooplankton samples, comprised by copepods, amphipods, euphausiids, and chaetognaths, was conducted during FY2006. Gladis Lopez, Ph.D. student at CICIMAR, Mexico, was instructed in stable isotope analysis of the zooplankton samples at the University of Hawaii, Stable Isotope Biogeochemistry Laboratory. Bulk $\delta^{15}N$ values of mesozooplankton exhibited the same geographical trend as the $\delta^{15}N$ values of bulk white muscle tissue (WMT) of yellowfin tuna (see next paragraph), providing further evidence that the geographical variability we are observing is due to variability in the $\delta^{15}N$ at the base of the food web. Bulk $\delta^{15}N$ values of yellowfin WMT and mesozooplankton were compared to derive estimates of yellowfin trophic level over a range of latitudes in the ETP, and the estimates agreed well with trophic level estimated by other methods (see next paragraph).

We have also analyzed the nitrogen isotopic composition of individual amino acids in yellowfin tuna samples from the ETP (see Graham et al. 2006b). We used the $\delta^{15}N$ of individual amino acids to distinguish changes in the $\delta^{15}N$ at the base of the food web from changes in the trophic level of yellowfin tuna from the ETP. The $\delta^{15}N$ of bulk WMT increased by about 5‰ from 10°S to 25°N in the ETP and can be attributed to variations in yellowfin trophic level and/or to changes in the $\delta^{15}N$ at the base of the food web. The $\delta^{15}N$ of essential amino acids (EAA) and nonessential amino acids (NAA) in tuna parallel the change in the $\delta^{15}N$ of bulk WMT, indicating that the observed trend of increasing ^{15}N enrichment with increasing latitude is due to changes in $\delta^{15}N$ at the base of the food web. Tuna trophic level estimated from the difference between the $\delta^{15}N$ of EAA and NAA (4.5±0.1) compares favorably with trophic level estimated by the difference between the $\delta^{15}N$ of yellowfin and mesozooplankton (4.2±0.4), and by previous yellowfin diet analyses (4.6-4.7). Our results set the stage for the application of compound-specific stable isotope techniques to support ecosystem-based approaches for the management of pelagic tuna fisheries.

Thirty-six samples of pelagic predators were submitted to B. Fry for sulfur isotope ($\delta^{34}S$) and total mercury (THg) analyses. Preliminary $\delta^{34}S$ data supports the ontogenic trophic shift observed in juvenile yellowfin tuna collected around Hawaii (Graham et al. 2006a) and, therefore, could help to distinguish foraging depth of pelagic predators. THg data is pending and will eventually be coupled with our existing THg dataset.

Modeling and Diet Analyses

The diet data for skipjack, albacore, yellowfin, and bigeye tunas from the warm pool (equatorial western Pacific) have been partially analyzed. The diets of the four tunas show relatively low overlap, and are differentiated by the tunas' vertical distribution and behavior. Skipjack eat only epipelagic prey, mainly fishes, with a very high cannibalism rate and low prey diversity. Yellowfin also eat mainly surface prey, but also some deep organisms. Bigeye and albacore have high percentages of deep-dwelling prey in their diets. The diets of skipjack and yellowfin, and of albacore and bigeye, are often similar taxonomically, but are different in terms of prey size.

Work to develop an ecosystem model, based on Ecopath with Ecosim (EwE), for the western Pacific has continued. Diet data were included for six forage components, following the SEAPODYM model, which are based on their depth distribution and vertical migratory behavior. Although an improved model could not be obtained, the work was useful for furthering our understanding of the ecosystem and highlighting some factors and groups that need better parameterization.

The diet data for 37 tunas and associated species from the cold tongue (equatorial eastern Pacific) have been partially analyzed. The data reveal significant predation by sharks, wahoo, and barracuda on juvenile tunas. Cephalopods, especially jumbo squid, are a key prey item for several predators, supporting the concept that squid are a keystone prey in the pelagic ecosystem. Several small fishes that associate closely with floating objects, such as triggerfish, kyphosids, lobotids, and mackerel scad, feed on algae, gastropods, and crustaceans that live on or near the objects.

The current EwE model for the pelagic ecosystem of the eastern Pacific will be reformulated based on new diet and stable isotope data from this project. These data are being compiled as more samples are analyzed.

A preliminary comparative study was carried out using diet data for skipjack, yellowfin, and bigeye tunas from the eastern and western Pacific. The fish caught by different fishing gears had different diets. The tunas caught by longline had a higher diversity of prey than tunas caught by purse seine. Longline and purse seine sets target different size tuna at different times of the day and at different depths. Differences in the diet descriptions from the two sampling gears need to be clarified, and stable isotopes are promising for this purpose.

Western Pacific Fisheries Information Network Project

P.I.: Thomas Schroeder [Michael Quach]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

The Western Pacific Fisheries Information Network Project, funded through JIMAR (referred to here as WPacFIN JIMAR), is an ongoing project that partners with and supports the primary Western Pacific Fisheries Information Network Program (referred to here as the WPacFIN Program) based at the Pacific Islands Fisheries Science Center (PIFSC). WPacFIN JIMAR focuses on improving the availability of accessible, timely, and high-quality fisheries data needed for research and fisheries management.

The WPacFIN Program improves the data processing and management capabilities of fisheries scientists, researchers, and managers at JIMAR, the University of Hawaii, the National Marine Fisheries Service, and the Western Pacific Fisheries Management Council (WPFMC). It also gives technical support to participating fisheries agencies in American Samoa, Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). The WPacFIN Program integrates local and federal island data, shares them through data share agreements, and manages them in the WPacFIN Program's central office at PIFSC. The WPacFIN Program also provides direct access to data for authorized users and fulfills data requests for researchers and fisheries management agencies.

In support of the WPacFIN Program, WPacFIN JIMAR primarily provides applications development/maintenance and technical support for American Samoa and Hawaii. WPacFIN JIMAR staff also assist in producing routine annual report products such as the Fisheries of the United States (FUS), Fishery Statistics of the Western Pacific (FSWP), and status reports for the Bottomfish and Pelagics Fishery Management Plans for American Samoa and Hawaii. They also update and maintain the WPacFIN Program web site at the PIFSC, which

provides public access to nonconfidential fisheries data, charts, various reports, and general information on related fisheries and island agencies.

Progress During FY 2006

In the past year, WPacFIN JIMAR made significant progress in providing technical support and applications development. Project staff designed, programmed, and implemented numerous computer applications in the island agencies and in the WPacFIN Program office at PIFSC. These applications process a wide range of data collected by fisheries researchers in the island agencies and make these data available to authorized users. Several existing applications also were redesigned and reprogrammed to address changes in the fisheries and requirements. Specific WPacFIN JIMAR accomplishments in FY2006 include:

1. Creating and producing numerous data summaries and summary reports to meet ever-increasing end-user and management needs.

2. Improving and standardizing the American Samoa shore-based data collection methodology.

3. Completing the second phase of designing and implementing the American Samoa shore-based creel survey data expansion program. Great efforts were made to archive all historical data and store them in the newly designed database for future data retrieval.

4. Revising and improving the automated production of Bottomfish and Pelagic Plan Team annual reports for American Samoa and Hawaii.

5. Improving production of FSWP and FUS reports.

6. Creating data summaries for the FUS report module.

7. Completing Volume 21 of the FSWP.

8. Significantly upgrading and modifying of the WPacFIN Program web site (URL: http://www.pifsc.noaa. gov/wpacfin/).

9. Good progress in the reconciliation and integration system for the Fisherman and Dealer data systems maintained by the Hawaii Division of Aquatic Resources (HDAR) to create the "best available" commercial landings data set. Data are currently being analyzed, and integration methodology documentation is in development.

10. Fulfilling numerous data requests from the WPFMC, the Pacific Islands Regional Office, and PIFSC.

WPacFIN JIMAR successfully carried out most of the proposed tasks for FY2006 that were identified in FY2005. The outstanding service and support of the WPacFIN JIMAR staff have contributed greatly to the mission of the WPacFIN Program. However, considering funding constraints, we elected to focus on top-priority tasks and on fulfilling the increasing demand for data requests for Hawaii and American Samoa data. As a result, a few lower-priority goals remain uncompleted this year. These are: 1) system development documentation; 2) data processing documentation; and 3) development of an application and database to store fishery-independent data collection for American Samoa's Department of Marine and Wildlife Resources. We anticipate working on these tasks in FY2006 as resources and priorities permit.

Protected Resources Environmental Compliance Initiative

P.I.: Thomas Schroeder [Chris Yates]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Regional Office

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

Develop and implement strategies to further recover marine species protected under the Endangered Species

Act (ESA) and /or the Marine Mammal Protection Act (MMPA). Conduct section 7 consultations under the ESA. Revise and maintain the marine mammal stranding program to fulfill mandates of the MMPA. Assist in the analysis and procedural requirements to manage federal fisheries in compliance with the ESA and the MMPA. Develop and deliver outreach and education campaigns for the public concerning protected resources issues. Project provides supplementary staff to augment federal employees assigned to this mission.

Progress During FY 2006

The objectives established for this period included: 1) sea turtle conservation, management and fisheries related mitigation activities within the PRECI; 2) draft informal section 7 consultation responses to other federal agencies in response to their submissions of project plans and permit applications; 3) draft ESA biological opinions and MMPA negligible impact determinations to analyze the specific actions on marine mammals; 4) research and review species for the NOAA Fisheries Convention on International Trade in Endangered Species of Wild Flora an Fauna (CITES) Task Force; 5) prepare, review and analyze scientific and policy documents concerning management of marine mammals in the Pacific Island Region; 6) provide marine mammal biological expertise during the preparation and review of management and policy documents; 7) assist in outreach and education mission by developing outreach materials, coordinating volunteer groups and creating partnerships with other federal and state agencies and non-profit organizations involved in protected resource issues; 8) provide administrative support to federal and JIMAR project staff in the Protected Resources Division.

During FY 2006, the following were accomplished: three new employees were hired: a marine mammal biologist, a regulatory specialist and an outreach and education specialist. JIMAR staff were involved in the drafting a biological opinion for the U.S. Western and Central Pacific Purse Seine Fishery as authorized by the South Pacific Tuna Act and the High Seas Fishing Compliance Act in order to analyze whether the action is likely to jeopardize the continued existence of any endangered or threatened species in the action area; reviewed, organized and analyzed public comments pertaining to the spinner dolphin Advanced Notice of Public Rulemaking (ANPR); researched and reviewed three species for the NOAA Fisheries Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) task force, which is an international body created to monitor the trade of land and marine plants and animals; organized the Pacific Islands Region Species of Concern workshop, the purpose of which is to gather information and ideas that can be used in the development of the regional Species of Concern Program and ultimately implement proactive conservation under the ESA to prevent species from being listed with a threatened or endangered status, rather than only addressing the recovery of species after they have been listed; prepared, reviewed and analyzed scientific and policy aspects of the Hawaiian Monk Seal Recovery Plan, which is the formal plan for recovering monk seals; assisted in the preparation of the Negligible Impact Determination for the Central North Pacific stock of humpback whales, which is a process under the MMPA that analyzes human impacts on marine mammals; provided administrative and technical guidance for the Honu Guardian volunteer program at Laniakea which provides outreach and education about the Hawaiian green sea turtle and proper wildlife viewing for visitors to the beach and mitigates human interactions with the sea turtles; organized and facilitated Hawaiian Monk Seal Outreach and Education Sharing Session at the Marine Mammal Responder Network conference; and created outreach materials concerning Hawaiian monk seal and marine mammal stranding issues. Various sea turtle projects abroad were continued and supported by staff. These included the Marshall Islands Sea Turtle Fisheries Interaction Outreach Education Project Phase 2, the Yap State Marine Turtle Project and the Population Dynamics of Sea Turtles at the Commonwealth of the Northern Mariana Islands (CNMI). The Marshall Islands project provides both fisheries-sea turtle interaction mitigation activities (including turtle handling and de-hooking techniques training) with the Marshall Islands Marine Resources Authority (MIMRA) and training for the members of Women United Together in the Marshall Islands (WUTMI) on sea turtle biology and conservation. The Yap State Marine Turtle Project is a capacity building project repeating a study done in the early 1990s to determine migration patterns of various species of sea turtles in the region. The CNMI project includes near-shore tow-surveys and cliff-line surveys to estimate distribution and abundance of turtles in CNMI and the regular monitoring of three nesting beaches. JIMAR PRECI staff also developed key processes and implemented administrative functions and budget planning and implementation for Federal and JIMAR staff.

Regime Shifts and Recruitment in Western and Central Pacific Ocean Tuna Fisheries

P.I.: John Sibert [David Kirby]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Center

NOAA Goal(s)

- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-base management

- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

To detect and characterize long-term environmental variability in time series of physical, biological and fisheries data; to determine whether the 'regime shifts' documented for the North Pacific are evident in the tropical WCPO; and to incorporate indicators of long-term environmental variability in tuna recruitment estimation.

The project has three components, each of which has a PI and Research Assistant (RA).

i) Exploratory data analysis of ecosystem model input/ouput plus comparable datasets, using various methods for multivariate time-series analysis to derive ecosystem indicators (PI: David Kirby; RA: Karine Briand)

ii) Use ecosystem indicators to improve recruitment estimation for tunas in the stock assessment software MULTIFAN-CL (PI: Adam Langley; RA: Karine Briand)

iii) Stomach contents analysis for data pre- and post the regime shifts of the late 1970s and 1990s (PI: Valerie Allain; RA: Marie-Laure Coudron)

Work to date has addressed Components (i) and (iii) concurrently. Effort will be directed to Component (ii) after the work under Component (i) has progressed sufficiently.

Progress During FY 2006

Component (i)

Many statistical methods are available to detect trends and changes in time series data. Multivariate analytical methods have been used in several studies of regime shifts in the North Pacific. We reviewed some of these methods in order to apply them in the tropical Western and Central Pacific region. Among the investigated methods, we focused particularly on: PCA (Principal Component Analysis), DFA (Dynamic Factor Analysis), MAFA (Min/max Autocorrelation Factor analysis), Chronological clustering and Fisher Information. A few other methodological approaches exist and need to be tested.

A preliminary analysis was made using environmental data derived from the ESSIC (Earth System Science Interdisciplinary Center, University of Maryland) ocean general circulation and biogeochemical model and the SEAPODYM (Spatial Ecosystem And Populations Dynamics Model) ecosystem model. Five environmental variables (temperature, primary production, east-west current component, north-south current component, epipelagic prey) were extracted from a fixed region (120°E-160°W; 10°N-10°S), which roughly defines the equatorial band encompassing the tropical Warm Pool. Two other Pacific climatic indexes (PDO, SOI) were added. Trends in those times series were investigated using the MAFA method implemented in the software package Brodgar 2.5.1 (www.brodgar.com). MAFA analysis is a type of principal component analysis designed for time series. A trend is defined by a long term change in the mean level or slow moving curve and is characterized by a high autocorrelation with time lag 1. MAFA estimates axes that have a decreasing autocorrelation with lag 1. So the first axis has the highest autocorrelation and shows the main trend in time series, then other axes represent less important trends. Figure 1. presents preliminary results.

The MAFA method is a good way to visualize the principal axes of variability in multiple time series and to relate each trend to the original data using loading factors. For example, Axis 1 has a linear trend that changes from positive to negative values in the late 1970s, and the trend denoted by Axes 2 & 3 reverse (Axis 2) or change (Axis 3) direction at the same time; these factors may serve as indicators of a regime shift. The trend of Axis 2 is associated with several environmental variables in the warm pool region (temperature, primary production, preys in decreasing order of loading factor) but it is not related to the climatic indices SOI or PDO, which both have very low loading factors on Axis 2. The PDO is associated with Axis 1 and SOI, somewhat surprisingly, is not

well represented on any axis. Further analysis will explore these issues in more depth.

Component (iii)

Two datasets from tuna (yellowfin, albacore, bigeye) stomach contents studies conducted in the same area (New Caledonia) and collected with similar gear (longline) but at two different periods (1959-1974 and 2001-2004 respectively) have been compared. The older dataset (Grandperrin 1975) is poorly detailed and highly aggregated as number of prey by species; the more recent data, which is very detailed, was then aggregated to match the format of the older dataset and allow comparison.

Differences were observed between the two datasets: albacore shows an increase in crustacean consumption; albacore and yellowfin show an increase in fish consumption and a decrease for cephalopods; while bigeye shows the opposite trend, with a decrease in fish and an increase in cephalopods. The diversity of fish prey by species and family appears to have decreased, with tuna now eating a narrower range of prey.

When considering the prey items by functional groups defined according to their depth distribution and vertical migration behaviour, albacore diet composition shows little differences between the two time period.

Figure 1. Underlying trends in environmental variables and climatic indices identified for the Western Pacific Warm Pool region by MAFA (Minimum/maximum Autocorrelation Factor Analysis). Numbers 1-3 indicate the different axes.
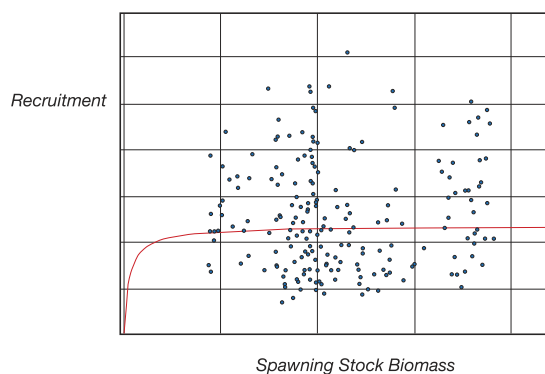
Figure 2. A typically uninformative Beverton-Holt recruitment vs. spawning stock biomass curve for yellowfin tuna used in the 2005 assessment. Environmental indicators will be used to improve the estimation procedure by incorporating decadal variability.

Conversely, yellowfin now seem to eat shallower prey, with an increase of epipelagic fish prey in their recent diet, while mesopelagic fish and mollusks have decreased. Bigeye seem to now eat deeper prey, with decreased consumption of epipelagic fish prey but an increase in mesopelagic mollusks.

While these differences were observed, the quality of the 1975 dataset did not allow any statistical significance testing and the number of samples examined is sometimes very low, particularly for bigeye. Conclusions must therefore be considered as indicative of the potential for ecosystem regime shifts to affect tuna diet and ecosystem interactions.

Marine Turtle Conservation and Management Initiative

P.I.: Thomas Schroeder [Charles Karnella]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Regional Office

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

In many coastal and island communities in the Pacific, marine turtles have long been known as a food source and can play important cultural roles in the lives of the inhabitants. Six marine turtles species: green, hawksbill, olive ridley, leatherback, loggerhead and flatback turtles inhabit the Pacific, especially the marine areas of Melanesia. Additionally this is an area of growing commercial fishing fleets, specifically using longline and purse seine

gear types. The purpose of this project is to introduce fishermen, fishery administrators, policy makers and other relevant stakeholders information and materials designed to increase the opportunities for survival by marine turtles that might be captured during the course of pelagic fishing operations in the exclusive economic zones (EEZ) of the Solomon Islands and New Caledonia (this action will augment NOAA Fisheries supported marine turtle conservation activities already underway in Papua New Guinea and Indonesia).

Progress During FY 2006

Solomon Islands Sea Turtle-Fisheries Interaction Outreach Education Project

Subsequent to implementation of this initiative, operations of the domestic-based longline fleet were placed in limbo in August 2005 when the Solomon Islands' Inland Revenue Division impounded vessels for the company's failure to pay taxes. The dispute continued for several months with the company fighting the charges, but the case was rendered moot when a destructive hurricane wrecked the boats in February 2006.

Communications and contacts with Solomon Islands officials proved difficult, so it was decided to discuss details of project activities and an appropriate timetable in Noumea at the SPC Heads of Fisheries meeting in March 2006. It was believed at the time that the project would still be useful to Solomon Islands, in that the fishery resource would be attractive to other foreign investors and that the Honiara site would at some point be utilized for domestic-based fishing.

National elections were held in Solomon Islands on April 5, 2006. When a new Prime Minister was announced on April 18, violence and civil unrest broke out in the capital, Honiara, with highly destructive riots lasting 3 days. These events resulted in the intervention of the Australian military to restore law and order. The Australian military intervention force is still present. Although a measure of calm has returned to the capital, it is highly unlikely that foreign investors will be encouraged to re-start the domestic-based longline fishery any time soon, if at all. Taken together, these events have called into question the practicality of continuing to implement the project in Solomon Islands.

NOAA Fisheries will continue to monitor the situation with the Solomon Islands government and fisheries and investigate opportunities to implement the project through the next fiscal year.

New Caledonia Sea Turtle-Fisheries Interaction Outreach Education Project

During March 27 through April 11, 2006, a NOAA Fisheries contractor attended the Secretariat of the Pacific Community (SPC) Heads of Fisheries Meeting in Noumea, to obtain information necessary to develop an implementation plan for a Sea Turtle-Fisheries Interaction Education and Outreach Project in New Caledonia. Anecdotal information was collected on current status of New Caledonia commercial tuna fishing fleet, relevant government institutions and departments necessary to plan and execute the project. Availability and rough costing of equipment and supplies necessary to conduct the project were obtained. Verbal agreement was reached with Marine Marchande and SPC that SPC would be responsible for local execution of the project including local purchase of equipment and supplies. The Training Section of SPC will be the contact point for that organization.

The project will consist of a series of training workshops and meetings in the two ports from which the tuna longline industry operates in New Caledonia: Noumea in the southern province and Koumac in the northern province. An outside consultant will conduct each workshop, with assistance from SPC Marine Resources Division personnel. Individual informational meetings will also be held with the staff of Marine Marchande and senior management at the various firms engaged in tuna longline fishing in New Caledonia.

NOAA Fisheries is presently working with SPC and a contractor to provide required documentation to JIMAR so contracts may be drafted and the project implemented.

Coastal Research

The JIMAR Administrative Board approved the addition of Coastal Research as the sixth JIMAR research theme at its November 2000 meeting. Subsequent to this decision, two initiatives have focused further attention on this emerging research area. NOAA has established a Coastal Services node in Honolulu and President Clinton designated the Northwest Hawaiian Island as a national refuge. To date, JIMAR research has been directed at issues related to coral reefs, a major component of the coastal zones of Hawaii and U.S.-affiliated Pacific Islands.

Coral Reef Management Initiative

P.I.: Thomas Schroeder [Alan Everson, John Naughton]

NOAA OFFICE (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Regional Office

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

To enhance the management of coral reef habitat throughout the US Pacific Islands. The goal of Coral Reef Management Initiative (CRMI) is to establish an enhanced coral reef management presence within the existing NMFS, Pacific Islands Regional Office (PIRO), Habitat Conservation Division (HCD). The CRMI relates directly to the JIMAR Coastal Research theme of achieving sustainable balance between the forces of coastal development and preservation. Information obtained as a result of CRMI assists resource managers in attaining this goal. It also enhances interagency cooperation and information exchange as well as develop new technologies for coastal resource management. A major

Participatory, learning and action workshop held in Aoa Village, American Samoa.

focus of this initiative is to investigate approaches to develop appropriate compensatory mitigation for coastal construction related loss of coral reef habitat, including but not limited to conducting follow-up studies of several coral reef mitigation projects. A coral reef classification system will be developed for use in habitat management decisions made by the HCD. The initiative will also enhance our capacity to address coral reef conservation issues in Guam, CNMI and American Samoa., as well as aid in the development of an integrated GIS-based system to evaluate anthropogenic impacts to corals reef.

Progress During FY 2006

Staff continued to participate with EPA, US Fish and Wildlife Service (USFWS), Army Corps of Engineers, the State of Hawai'i and the Government of Guam in the Pacific Region Interagency Coral Reef Mitigation Working Group (PRIWG) as part of the process of standardizing mitigation plans for marine projects. One method for assessing mitigation alternatives is to conduct a habitat equivalency analysis (HEA). An HEA model is currently being used as a pilot project for determining mitigation for the expansion of an ammunition wharf on a Navy base in Guam (Honolulu and Guam staff participated in intensive field work to support the assessment.) Staff continued restoration work associated with the Cape Flattery ship grounding that occurred in 2005. Staff participated in an eradication project of the snowflake coral *Carijoa riisei* in Port Allen, Kauai. Staff also assisted the Department of Defense in conducting an assessment of a former munitions disposal site off Pokai Bay, Oahu, Hawaii. Staff participated in the development of a GIS-based management of the bottomfish fishery in Hawai'i, which was recently designated as being over fished. Over 6,300 fishing records have been incorporated into the GIS map to date which includes coordinates, depths, dates, times, species caught, length, weight, sex, and reproductive stages.

Staff in American Samoa held Participatory, Learning, and Action workshops for 2 local villages to engage

community members in information gathering, developing, and implementation of coral reef resource management. In CNMI staff held forums for fishers to increase their awareness and participation in fisheries management decisions. Staff in CNMI also developed and produced a series of public information shows on coral reef conservation and management that were broadcast on a local radio station. These have been well received by the public and will continue in 2007. CNMI staff also continued with a survey on fisher perceptions and a marine attitude and knowledge survey for local high schools. A field office was established in Guam to address local coral reef management issues. Staff in Guam implemented a marine debris education campaign with a goal of increasing public awareness of marine debris impacts and promoting stewardship for coastal and marine resources, and thus reducing the level of shore-based marine debris and derelict fishing gear affecting Guam's coastal environment. In addition, staff located in American Samoa, Guam, CNMI and Hawaii coordinated Local Action Strategies for inshore coral reef fisheries management. These activities included revising the action plans, presiding over planning meetings and ensuring the goals and objectives of the various plans are met.

In summary, all of our 2006 objectives were met.

National Environmental Policy Act (NEPA) Initiative

P.I.: Thomas Schroeder [Charles Karnella]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Regional Office

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

Under the Federal National Environmental Policy Act (NEPA), federal agencies must insure that environmental information is made available to public officials and citizens before decisions are made and actions are taken. The purpose is to promote management and policy decisions that will prevent or eliminate damage to the environment, stimulate health and welfare of man and enrich understanding of ecological systems and natural resources important to the Nation. The major focus of this initiative is to obtain technical assistance on an activity- and project specific basis to ensure timely and legally sufficient agency compliance with applicable NEPA requirements. The initiative addresses National Marine Fisheries Service's NEPA compliance with international treaties as well as fosters international marine resource conservation measures. While National Marine Fisheries Service has addressed NEPA compliance associated with Federal activities (i.e., development of fishery management plans) in the past, this NEPA Initiative represents a holistic effort to foster compliance with NEPA in international projects. Information and lessons learned from this NEPA Initiative will be evaluated and applied to future NEPA actions. NEPA focused hires under this initiative will closely coordinate and collaborate with several existing organizations with marine resource protection mandates. These include, but are not limited to NOAA Pacific Islands Region Fisheries Science Center, NOAA National Ocean Service, NOAA and National Marine Fisheries Service headquarters components, and the Western Pacific Fishery Management Council.

The primary purpose of the NEPA initiative is the development of a NEPA analysis for the Western and Central Pacific Fisheries Commission (WCPFC).

Progress During FY 2006

Recruitment concluded with the hiring of the International NEPA Project Manager (February, 2006) and International NEPA Administrative Assistant (January, 2006). The WCPFC implementing legislation has not been forthcoming and efforts have focused on anticipatory actions. Complicating factors related to, among other things, environmental effects abroad, agency discretion and the scope of analysis required have resulted in the need for extensive research and strategy development. Recognizing the need for a broad programmatic NEPA analysis, research to establish the baseline condition and develop the affected environment (Chapter 3) materials has progressed substantially. Administrative record keeping and documentation schemes are being constructed. An initial outreach and education effort was conducted and public participation invited through public meetings held in Honolulu and San Diego.

Sustaining Healthy Coastal Ecosystems

P.I.: Thomas Schroeder [Russell Brainard]

NOAA Office (of the primary technical contact): National Marine Fisheries Service/Pacific Islands Fisheries Science Center

NOAA Goal(s)

• To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

To address concerns about the deterioration of coral reef ecosystems around the globe, this project supports multi-disciplinary efforts to assess, monitor, map, restore, and protect coral reef ecosystems of the U.S. Pacific Islands. The goals of this program are to:

• improve understanding of coral reef ecosystems through assessment, long-term monitoring, and applied research,
• evaluate and reduce adverse impacts to coral reef ecosystems with particular emphasis on those related to fishing activities,
• enhance coral reef fisheries management and conservation by providing scientific support for implementation of the Coral Reef Ecosystem Fishery Management Plan, and archipelagic-based ecosystem management plans, and
• provide the scientific basis to expand, strengthen, and establish marine protected areas (MPAs) to conserve coral reef resources of the U.S. Pacific Islands.

Progress During FY 2006

Program Progress Overview

The JIMAR Sustaining Healthy Coastal Ecosystems program is funded by NOAA Coral Reef Conservation Program and is staffed by over 50 researchers, support personnel, and graduate students. This includes 41 full-time personnel and 9 U.H. graduate students that are employed through the Joint Institute of Marine and Atmospheric Research (JIMAR). The research accomplishments and success of the program has been critically dependent on the expertise and efforts of JIMAR scientists and staff in the Coral Reef Ecosystem Division (CRED) and the Pacific Islands Fisheries Science Center (PIFSC).

In order to support the objectives of the JIMAR Sustaining Healthy Coastal Ecosystems program plans for FY2006 included:

• to continue long-term monitoring and assessment of fish, corals, algae and macro-invertebrates in coral reef ecosystems of U.S. Pacific Islands
• to continue long-term monitoring of the oceanographic environment of coral reef ecosystems of U.S. Pacific Islands
• to complete mapping of coral reef habitats in U.S. Pacific Islands
• to continue long-term marine debris removal in the Northwestern Hawaiian Islands (NWHI)
• to initiate a marine debris removal program in the Main Hawaiian Islands (MHI) based on aerial surveys

During FY2006, the Sustaining Healthy Coastal Ecosystems program conducted multi-disciplinary research cruises aboard the NOAA Ships Oscar Elton Sette and Hiialakai in U.S. Pacific Islands. These research cruises conducted assessments and monitoring of the fish, corals, other invertebrates, and algae in the context of their benthic and oceanographic habitats of the coral reef ecosystems of the MHI, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), American Samoa, U.S. Line Islands, U.S. Phoenix Islands, Wake Atoll, and Johnston Atoll. These research cruises also conducted benthic habitat mapping activities consisting of multi-beam acoustic surveys and towed diver and towed camera optical validation surveys. This multi-disciplinary approach to research provides an improved understanding of coral reef ecosystems, which will serve as the scientific basis for management plans and conservation efforts. Program activities that evaluate and reduce adverse impacts to coral reef ecosystems included marine debris removal efforts in the NWHI and MHI.

During 20-24 February 2006, JIMAR and PIFSC scientists delivered 14 oral or poster presentations representing coastal ecosystem work accomplished through CRED at the AGU/ASLO Ocean Sciences Meeting in Honolulu. The presentations highlighted CRED's coral reef assessment, monitoring and mapping activities at U.S.-affiliated

islands throughout the Pacific Ocean. The 5-day conference included nearly 5,000 registered participants. CRED talks included:

Coral Reef Ecosystem Integrated Observing System (CREIOS) in the Pacific:
- Infrastructure for Monitoring, Modeling, and Management of U.S. Coral Reef Resources
- Biodiversity and Abundance of Organisms on Coral Reefs Across the Pacific
- Passive Acoustic Monitoring of Biological Activity on Coral Reefs and in Nearby Waters
- Spatial Distribution of the Coral Genus Acropora at French Frigate Shoals
- Nitrogen Isotope Ratios in Algae on a Remote Coral Reef

CRED posters included:
- The Relationship of Coral Reef and Open Ocean Water Temperatures: Estimation of Coral Reef Flushing Rates from Bulk Parameterization of Heat Flux
- Long-term Effects of a Ship Grounding on Coral Reef Fish Assemblages at Rose Atoll, American Samoa
- Upwelling Variability Near a Remote Equatorial Pacific Island and its Influence on Coral Reef Ecosystem Dynamics
- Bottom Camera Bait Stations
- Seafloor Mapping and Characterization in the Hawaiian Archipelago
- The Influence of Wave Energy on Spatial Variation in Coral Reef Morphology: Midway Atoll

Ecological Assessment—Fish

Ecological assessments of reef fish were conducted in the summer-fall of 2005 from the NOAA Ship Oscar Elton Sette in the MHI (14 July-7 August); in the Marianas Archipelago (CNMI and Guam, 16 August-9 October); and around Wake Atoll (12-30 October). In the winter-spring of 2006 assessments were conducted from the NOAA Ship Hiialakai around Johnston Atoll and the U.S. Phoenix Islands (Howland and Baker, 15 January-5 February); American Samoa (9 February-10 March), and in the U.S. Line Islands (Jarvis, Palmyra, and Kingman, 15 March- 8 April).

In the MHI, fish assessments were expanded to 50 Rapid Ecological Assessment (REA) sites around Kauai, Niihau/Lehua Rock, Oahu, Molokai, Maui/Molokini, and Lanai. In addition, 86 towed-diver fish surveys were completed around these same islands. Generally, fish stocks appeared

*Schooling convict surgeonfish (*Acanthurus triostegus*) at Rose Atoll, American Samoa (photo by Robert Schroeder).*

to be heavily depleted at all of the islands surveyed in the MHI. Large fish, predators, and other commonly fished species were rare or absent at almost all sites, especially in comparison to the predator-rich NWHI. When present, predators and fishery species were often small. Fish density was highest at Lehua Rock and followed in decreasing order from Niihau to Lanai, Kauai, Oahu, Molokini, Molokai, and finally Maui. The total number of coral reef fish species that CRED documented for each of the islands was 143 for Kauai, 131 for Lanai, 127 for Oahu, 114 for Niihau, 108 for Maui, 107 for Molokini, and 96 for Lehua. At all reefs, the most common family was wrasse (*Labridae*), followed by surgeonfish (*Acanthuridae*), butterflyfish (*Chaetodontidae*), and damselfish (*Pomacentridae*), except at Molokini, where more species of butterflyfish were observed than surgeonfish.

In the Marianas Archipelago, 74 fish REA monitoring sites (established during our 2003 cruises) were resurveyed around 21 islands/banks. A total of 140 towed-diver fish surveys were also completed around these islands. Overall, fish assemblages around the CNMI were basically similar to that found during our first assessment cruise 2 years prior, while several differences were noteworthy. Large fish appeared less abundant around Uracas and no large grouper (*Epinephelus lanceolatus*) were seen. Otherwise, the general trend still indicated a greater abundance of larger fish in the northernmost islands compared to the southern islands as a result of fishing pressure associated

with the great number of people in the southern islands. Medium-large fish were moderately abundant on the western banks. In general, sharks were of very low abundance throughout the archipelago, but slightly more common at Asuncion, Zealandia, Agrihan, and Pathfinder. The most common fish (by numbers) were damsels and small wrasses (especially in the south), many exhibiting good recruitment pulses (e.g., *Chromis acares, C. vanderbilti, Pomacentrus vaiuli*). A few Napoleon wrasses (*Cheilinus undulatus*) were seen at some islands mid-chain and south, including some large ones. No bumphead parrotfish (*Bolbometopon muricatum*) were seen in 2005, while several were seen in the archipelago in 2003. The fish census team observed no sharks around Guam, although the fish towed-diver surveys did observe black-tip and white-tip sharks. Large fish were not abundant at any of the sites surveyed. Surveys for large fish at each site suggest that fish larger than 25 cm are uncommon in most areas around Guam. This is not surprising considering that Guam sustains a large population and its waters are heavily fished. Quantitative belt transect surveys found fish larger than 20 cm to be uncommon in most areas around Guam. Heavy fishing and habitat loss are probable causes.

At Wake Atoll, fish were assessed and monitoring sites established for the first time at 13 REA sites and 19 towed-diver fish surveys were completed during five days of operations. Wake's reefs supported a healthy abundance of reef fish that are often severely depleted in more heavily exploited areas. An absence of spearfishing pressure was immediately noticeable as potentially wary species were easily approached by divers. Parrotfish of several species were exceptionally large, and the rare bumphead parrotfish (*Bolbometopon muricatum*) was encountered on nearly every dive. Napoleon wrasse (*Cheilinus undulates*) and several species of commercially exploited groupers were also frequently encountered. Most sites surveyed exhibited a high degree of similarity in terms of fish species composition, and there seemed to be little change with depth within the limits of our diving depth range. Few deep-water species were observed along the steep outer reef dropoffs. The lagoon of Wake was heavily impacted due to a cutoff of circulation following the construction of a causeway. Only one survey dive was conducted in the lagoon as visibility was near zero and fish fauna was patchily distributed on small coral bommies smaller than the length of our transect lines.

Fish REA monitoring sites established in previous years were resurveyed at Johnston Atoll (18 sites) and the U.S. Phoenix Islands (14 sites), and 27 towed-diver fish surveys were completed around Johnston Atoll and 16 around Howland and Baker Islands. The most striking observation of the fish team at Johnston Atoll was the low fish diversity. We recorded a total of 120 fish species. As was reported during the 2004 Johnston survey, many usually common species were seemingly absent. Also of note was the frequent observation of hybrid fish. Hybrids consisting of various characteristics of the three wrasses, *Thalassoma duperrey, T. quinquevittatum,* and *T. lutescens* were frequently observed, as was a single individual that appeared to be a hybrid of the two butterflyfish species, *Chaetodon auriga* and *C. trifascialis*. Numerically, three fish species dominated the fauna of the atoll. Collectively, the bullethead parrotfish (*Chlorurus sordidus*), the bluelined surgeonfish (*Acanthurus nigroris*), and the goldring surgeonfish (*Ctenochaetus strigosus*) made up nearly 50% of all the fish observed. Towed-diver surveys at Johnston Atoll revealed fewer fish and lower species diversity than expected. A persistent school of gray reef sharks was seen at the southwestern section of the atoll margin as were previously unobserved schools of large black and blue-fin trevally (*Caranx lugubris* and *C. melampygus*) within the southeastern section of the lagoon.

The reefs at Howland and Baker support a high density of reef fishes. While sharks were uncommon, many large snappers and parrotfish were encountered, as were medium sized groupers. A total of 210 fish species were recorded by the fish REA divers at Howland and Baker. Numerically, three fish species dominated the fauna of both islands. Collectively, Bartlett's anthias (*Pseudanthias bartlettorum*), Whitley's splitfin (*Luzonichthys whitleyi*), and the fusilier damselfish (*Lepidozygous tapeinosoma*) made up 60% of all the fish observed. Schools of these three species of small-bodied planktivores were observed at nearly every site with groups sometimes including thousands of individuals. Among larger bodied fishes, several species of surgeonfish were abundant along with the bigscale soldierfish (*Myripristis berndti*) and the smalltooth jobfish (*Aphareus furca*). While not observed along transects, Napoleon wrasse (*Cheilinus undulates*) were observed by the fish REA team at both islands along steep outer reefs. Being similar in location and overall morphology, Howland and Baker islands showed a marked difference in large fish assemblages from towed-diver surveys. Communities of gray reef sharks (*Carcharhinus amblyrhynchos*), common at Howland, were virtually absent at Baker, as were schools of scalloped hammerheads (*Sphyrna lewini*).

In American Samoa, 61 fish REA monitoring sites (established during our 2002 and 2004 cruises) were resurveyed and 116 towed-diver fish surveys were completed around the 7 islands. In general, fish assemblages around these islands appeared to be roughly similar in diversity, abundance, and community composition to

that of previous years, with a few exceptions. Tutuila, the largest island with the highest human population, still appeared to have lower densities of medium-large fish than the more remote, lightly populated islands. Sharks and jacks appeared to be even rarer around most of these islands than found in previous years. Several endangered Maori wrasse (*Cheilinus undulatus*) occurred around all islands, but no bumphead parrotfish (*Bolbometopon muricatum*) were seen by the fish REA team. No major or heavy, widespread recruitment pulses were occurring for any species during this season of monitoring. At the site of the 1993 longline vessel grounding at Rose Atoll, ecosystem disturbance was found to have persisted for over 12 years, even though the U.S. Fish and Wildlife Service have now removed the vast majority of debris. Cyanobacteria and turf algae remain abundant at the impact site as do schools of herbivorous fishes (e.g., surgeonfish).

In the U.S. Line Islands, 38 fish REA monitoring sites, established in previous years, were resurveyed and 52 towed-diver fish surveys were completed around Jarvis, Palmyra and Kingman. The reefs at Jarvis Island support an exceptionally high density of reef fishes. Sharks, groupers, jacks, and snappers were common at every REA site surveyed. A total of 165 fish species were recorded by the fish REA divers at Jarvis. Numerically, three fish species dominated the fish fauna here. Collectively, Bartlett's anthias (*Pseudanthias bartlettorum*), Whitley's splitfin (*Luzonichthys whitleyi*), and the fusilier damselfish (*Lepidozygous tapeinosoma*) made up 60% of all the fish observed. Schools of these three species of small-bodied planktivores were observed at nearly every site with groups sometimes including thousands of individuals. Among larger bodied fishes, black jacks (*Caranx lugubris*), spotted hind (*Cephalopholis miniata*), doublebar goatfish (*Parupeneus insularis*), and several species of surgeonfish were most abundant. Grey reef sharks (*Carcharhinus amblyrhynchos*), whitetip reef sharks (*Triaenodon obesus*), and manta rays (*Manta birostris*) were also abundant.

The fish observers collectively recorded 176 species of reef fishes at Palmyra. The three schooling planktivores that dominate the fish fauna of Jarvis Island were not nearly as abundant at Palmyra. The most abundant fish species based on REA surveys were dwarf chromis (*Chromis acares*), Vanderbilt's chromis (*C. vanderbilti*), and bicolor chromis, (*C. margaritifer*). Diversity was highest among wrasses (35 species recorded) and surgeon/unicornfishes (25 species). Large fish, including sharks, were generally less abundant than at Jarvis with the exception of the twinspot snapper (*Lutjanus bohar*), which was quite common. Napoleon wrasse (*Cheilinus undulatus*) and manta rays (*Manta birostris*) were encountered frequently but were rarely recorded within the boundaries of quantitative REA surveys.

Kingman Reef includes several habitat types that are not found at Jarvis or Palmyra. The sunken atoll consists of exposed outer reef, extensive back reef, a series of small, scattered patch reefs, and a sunken western atoll rim. The REA team was able to survey at least one site in each of these habitat types. A preliminary total of 186 fish species was recorded by the fish REA divers at Kingman Reef. Numerically, damselfish (*Pomacentridae*) dominated the fish fauna at Kingman, although the species composition varied more greatly from region to region at this island than at the other two islands surveyed during this cruise. Surgeonfish (*Acanthuridae*) were also very abundant at most sites surveyed by the REA team. Among larger-bodied fishes surveyed by the REA team, twinspot snapper (*Lutjanus bohar*) were abundant at every site surveyed. Large aggregations of yellowback fusiliers (*Caesio teres*), blackfin barracuda, (*Sphyraena qenie*), and rainbow runners (*Elagatis bipinnulata*) were observed at scattered sites. Sharks appeared to be more abundant here than at Palmyra, but less abundant than at Jarvis. The REA team at Kingman Reef observed no Napoleon wrasse (*Cheilinus undulates*) or bumphead parrotfish (*Bolbometopon muricatum*).

Analysis of fish data from these and previous years' cruises and subsequent manuscript preparation were also conducted during the year.

Ecological Assessment—Corals

During July-August 2005 aboard the NOAA Ship Hiialakai, JIMAR Marine Ecologist Dr. Jean Kenyon conducted coral reef community structure surveys in the MHI. Dr. Greta Aeby from the State of Hawaii's Department of Land and Natural Resources assisted Dr. Kenyon and also conducted coral disease surveys around the Islands. Later in September-October, a second year of surveying long-term monitoring sites in CNMI, Guam, and Wake Atoll was conducted onboard the NOAA Ship Oscar Elton Sette. JIMAR scientists worked cooperatively with partner scientists from CNMI's Division of Fish and Wildlife and Division of Environmental Quality as well as the University of Guam. Data pertaining to the coral fauna at Wake Atoll were collected by JIMAR scientist Dr. Jean Kenyon and Victor Bonito (Research Assistant, Florida Museum of Natural History).

In late October 2005, Dr. Bernardo Vargas-Angel was hired as the new Coral Disease Specialist. In January-April 2006, Dr. Vargas-Angel embarked on the NOAA Ship Hiialakai with other JIMAR scientists, as well as partners from U.S. Fish and Wildlife Service, Bishop Museum, University of Hawaii, and American Samoa's

Department of Marine and Wildlife Resources to conduct long-term monitoring surveys at Johnston Atoll, the U.S. Phoenix Islands, American Samoa, and the U.S. Line Islands. Dr. Vargas-Angel surveyed for coral diseases at 140 different sites along these islands. Highlights of the expedition included documenting the prevalence of coral disease, as well as observations and enumeration of afflictions to coralline algae. Additionally, Dr. Kenyon participated in coral surveys in American Samoa.

Later in June 2006, Coral Disease Specialist Dr. Vargas-Angel participated in the Coral Disease and Health Consortium Pacific Workshop: Vision for Action, aimed at promoting effective detection, identification, and management of coral reef diseases in the U.S. Pacific territories. Additionally, Dr. Vargas-Angel has formed an agreement with Dr. Ruth Gates (Hawaiian Institute of Marine Biology) to further the identification of molecular indictors of coral susceptibility to disease. Dr. Vargas-Angel has also initiated conversations with coral disease researches Drs. Greta Aeby and Thierry Work aimed at joining efforts to advance coral disease prevalence and characterization studies in the Hawaiian Islands as well as the U.S. Pacific territories.

Three manuscripts on which Dr. Kenyon is the lead author have been published so far in 2006. An additional manuscript that discusses coral bleaching in the Northwestern Hawaiian Islands observed during surveys conducted by Kenyon in 2004 is also scheduled for publication in 2006.

Ecological Assessment—Algae

Since the summer of 2005, 8 peer-reviewed manuscripts incorporating data collected by the CRED phycology lab have been published or accepted for publication. An additional 2 manuscripts are in review, and drafts are almost complete for 6 more.

Of manuscripts that were published, in press, or in review, 6 focus on the NWHI. The detailed analysis of benthic cover at French Frigate Shoals that has been underway since 2004 has resulted in 3 published manuscripts: a qualitative assessment of algal species, a quantitative assessment of benthic cover, and a qualitative assessment of scleractinian coral species. An additional manuscript looking at relative abundance of macroalgae across the entire NWHI archipelago based on in situ observations will be published in the proceedings of the Northwestern Hawaiian Islands' 3rd Scientific Symposium. One new species of red algae, named *Dasya atropurpurea*, was described from Pearl and Hermes Atoll. Finally, a benthic cover assessment for corals at Pearl and Hermes Atoll is in review at Pacific Science.

Algal manuscripts from outside the NWHI include: (1) a Pacific-wide assessment of algal vs. coral cover at some of the most pristine reefs remaining in the world; (2) a temporal comparison of relative abundance of macroalgae across the Mariana archipelago; (3) the description and molecular characterization of *Halimeda kanaloana* from Maui Nui; and (4) an analysis of algal data collected from Rota in the Mariana archipelago was combined with sea turtle observations to produce a manuscript linking turtle abundance with foraging patterns. In the first manuscript mentioned, a Pacific-wide study of benthic functional groups revealed that most healthy tropical reefs in the Pacific are dominated by algal functional groups rather than coral communities.

Analyses are completed and manuscripts almost complete for work discussing: (1) species-level benthic community analyses at Pearl and Hermes Atoll; (2) biotic and abiotic factors influencing algal and coral communities at Pearl and Hermes Atoll; (3) qualitative algal analyses of Howland and Baker Islands; (4) quantitative benthic and fish analyses at Howland and Baker Islands; (5) qualitative algal analyses of the CNMI; and (6) temporal comparison of relative abundance of macroalgae in American Samoa between 2004 and 2006.

Ecological Assessment—Invertebrates

The non-coral marine invertebrate component is conducted through a partnership between CRED and the Hawaii Biological Survey and Pacific Biological Survey of the Bishop Museum, both based in Hawaii. In the variety of locations in which surveys have been conducted, a set of target organisms are enumerated with quantitative techniques for the purpose of monitoring. In conjunction with the regular monitoring activities, the species richness of the various habitats present is gradually being assessed through the collection and identification of various taxonomic groups from these research cruises. With the addition of 2004-2005 survey results, the preliminary totals for species richness are: 885 species from 12 phyla for the NWHI, 396 species from 4 phyla for the Pacific Remote Island Areas (PRIA), and 507 species from 4 phyla for American Samoa. In FY2006, there were 2 new records for the Hawaiian Archipelago for trapezid crabs (*Tetralia glaberrima* and *T. muta*). Also, a new species of hermit crab from the genus *Dardanus* was identified from Howland and Baker Islands in the PRIA. Only a fraction of material collected for identification has been completed and the values reported here will increase greatly. These efforts also allow for alien species surveys to be conducted in these remote habitats. Data from the

CRED efforts have been combined with other surveys to compile records for alien species (marine invertebrates only). The current results for FY2006 are as follows: 7 species from 3 phyla for the NWHI, 13 species from 6 phyla for the PRIA and 26 species from 8 phyla for American Samoa.

Oceanography

Oceanographic monitoring and assessment continues throughout the NWHI, Guam, CNMI, American Samoa, and the PRIA. During the past year, the existing long-term monitoring network was expanded to 188 stations measuring various oceanographic and meteorological parameters, including sea surface and subsurface water temperature, salinity, current profiles, wave and tide data, photosynthetic active radiation, UV-B, air temperature, barometric pressure, and wind velocity at 44 islands and banks around the Pacific Ocean. In addition, closely spaced shallow water (30 m) conductivity, temperature, depth casts (CTDs); shipboard deepwater (500 m) CTDs; and acoustic Doppler current profiler transects are conducted during research cruises to provide a more detailed spatial (horizontal and vertical) description of oceanographic conditions. One

JIMAR researchers prepare to deploy the Bottom fish camera (BotCam) station in waters off the Commonwealth of the Northern Marianas Islands. The BotCam is a non-extractive method to collect information about bottom fish species in depths up to 350 meters.

thousand and eighty-three shallow water CTDs, approximately 200 shipboard deepwater CTDs, and thousands of kilometers of Acoustic Doppler Current Profiler data have been collected over the past year, expanding the program's existing oceanographic assessment data. Physical oceanographic data are complimented with in-situ water samples of chlorophyll (chlorophyll a, pheopigments) and dissolved nutrient concentrations (phosphate, silicate, nitrate, nitrite), with approximately 1900 and 1700 chlorophyll and nutrient samples collected during the past year, respectively. Other variables, such as dissolved inorganic carbon are being measured at certain locations as part of a collaborative effort with NOAA's Pacific Marine Environmental Laboratory.

Ocean circulation and archipelago connectivity studies are ongoing as the program continues to monitor satellite tracked oceanic drifters and work with the International Pacific Research Center on a collaborative effort to develop a numerical circulation model for the greater Hawaiian Archipelago.

In collaboration with the Hawaii Institute of Marine Biology (University of Hawaii), the program has developed and deployed a number of Ecological Acoustic Recorders, passive acoustic listening devices used to monitor the temporal and spatial patterns of changes in the ambient sound field at remote coral reef ecosystem locations. These time-series of passive acoustic datasets will provide coastal resource managers and enforcement personnel with the ability to remotely detect ecologically significant use of explosives.

The Bottomfish Camera (BotCam) station, currently under development by the program, is a non-extractive method to monitor exploited bottomfish populations and other important deep water species, visually assess habitat, and study ecological linkages to more shallow water ecosystems. Optical measurement tools represent an underutilized non-extractive method for collecting ecosystem observations of habitat and population parameters.

Benthic Habitat Mapping

Benthic habitat mapping of coral reefs is an important part of the JIMAR Sustaining Healthy Coastal Ecosystems work. Since 2001, surveys have been conducted in U.S.-affiliated Pacific Islands using bottom cameras, towed-diver surveys, and single-beam echosounders. In FY2003, a significant new mapping capability was added to this

program with the delivery of a 25-ft survey launch, R/V AHI, which is equipped with a 240-kHz multi-beam sonar. Extensive mapping was conducted in 2003-2004 at Midway; Saipan (Marpi Bank), Tinian (Tatsumi Reef), and Rota in the CNMI; Guam; and Tutuila, Ofu, Olosega, and Ta'u Islands in American Samoa. In 2004-2005, bathymetric data sets and metadata for all of these locations were submitted to the National Geophysical Data Center, and grids were made available through the web site, http://www.pifsc.noaa.gov/cred/hmapping/; backscatter data for these areas are also now available through this web site. In early 2005, the NOAA Ship Hiialakai with two multibeam sonars (30 and 300 kHz) started operations in the Hawaiian Archipelago, and over 100 days of seafloor mapping operations were conducted on five cruises in the Hawaiian Archipelago. All bathymetric data from the NWHI collected through the end of 2005 are currently available for download from a new web site (http://www.soest.hawaii.edu/pibhmc) for the Pacific Islands Benthic Habitat Mapping Center, a group that conducts mapping activities with Sustaining Healthy Ecosystems and Center for Excellence in Ocean Sciences (CEROS) funding through JIMAR.

Between January and April 2006, the NOAA Ship Hiialakai and the R/V AHI embarked upon a series of three cruises to the PRIA and American Samoa. In American Samoa, multibeam mapping of the north coast of Tutuila and around Swain's Island and Rose Atoll was completed, and additional optical data were collected around the Manu'a Islands. During

A diver utilizes liftbags to raise a large conglomerate of derelict fishing gear to the surface for removal at Pearl and Hermes Atoll, NWHI (photo by Amy Hall).

education and outreach portions of the cruises, officials from the American Samoa government and students from local high schools were shown mapping operations and presented with completed map and geographic information system (GIS) products. Multibeam data in water depths ranging from 5-3000 m were collected at Johnston, Howland, and Baker Islands on HI-06-01 and at Kingman Reef and Jarvis and Palmyra Islands on the return leg, HI-06-04. Multibeam mapping in the Hawaiian Archipelago continued on two cruises – HI-06-05 and HI-06-09. Additional MHI data were collected at Penguin Bank, N. Shore Molokai, Lanai, and the NW Big Island, and mapping was continued at Kure Island and Pearl and Hermes Atoll in the NWHI. A total of 10,000 km^2 of multibeam bathymetric data has been collected since 2003 and made available to partner agencies and

research groups within a few months of data collection. Significant progress has also been made in developing processing methods for backscatter and optical data, producing standard products from these data sets, and integrating the multibeam and optical data into seafloor characterization maps and GIS products.

Marine Debris Removal

The Marine Debris Team of CRED leads an immensely successful multiagency effort to remove derelict fishing gear from the reefs and beaches of the Hawaiian Archipelago. Since the inception of marine debris removal efforts in 1996, over 492 metric tons (MT) of derelict fishing gear have been removed from the NWHI and over 20 MT removed from the MHI. All derelict fishing gear removed since 2002 has been incinerated for Oahu energy production. The primary goals of this project are as follows.

The Marine Debris Team uses trucks and manpower to remove debris from Oahu's windward shores.

- Assess, document, and remove derelict fishing gear from the coral reef environments and islets of the NWHI.
- Assess, document, and remove derelict fishing gear from the coastal ecosystems of the MHI.
- Monitor debris accumulation in High Entanglement Risk Zones of the NWHI for the protection of the Hawaiian monk seal (*Monachus schauinslandi*).
- Monitor debris accumulation at specified NWHI reef sites to identify rates and patterns of ongoing accumulation.

While past marine debris survey and removal efforts have focused on the NWHI, this year the Marine Debris Team initiated a large-scale effort to address the problem in the MHI. In May 2006, the Marine Debris Team completed helicopter surveys assessing patterns in the distribution and abundance of marine debris in

A Hughes MD-500 helicopter was used to survey coastlines of the main Hawaiian Islands. During fifty hours of surveys, 711 debris sites were identified and marked with GPS for planned removal efforts.

the MHI. The following islands were successfully surveyed in their entirety: Oahu, Kauai, Hawaii, Kauai, Maui, Lanai, and Molokai. Surveys revealed the presence of derelict fishing gear along the shores and nearshore reefs of all islands; a total of 711 sites comprising an estimated 117 MT of marine debris were identified. Windward-facing shorelines contain substantially more derelict fishing gear than their leeward counterparts. This observation indicates that northeasterly trade winds play a primary role in debris deposition. NOAA/JIMAR personnel used data collected during aerial surveys to complete a cleanup of Oahu's coastlines in June 2006, removing >13 MT.

Over the past year, marine debris survey and collection activities in the NWHI were performed at French Frigate Shoals and Midway Atoll. During a two-month deployment at French Frigate Shoals in September 2005 on the M/V Freebird, the team completed surveys of the shallow benthic habitats, removing 17.8 MT of derelict fishing gear. In May-June 2006, a team consisting of NOAA/JIMAR and U.S. Coast Guard personnel traveled to Midway Atoll for 8 days of debris removal operations, removing 2.7 MT during land-based operations.

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Appendix I List of Acronyms

ADCP	Acoustic Doppler Current Profiler
ADPC	Asian Disaster Preparedness Center
ADRMs	Advection Diffusion Reaction Models
AFS	American Fisheries Society
AGU/ASLO	American Geophysical Union/American Society of Limnology and Oceanography
AIM	Ambient Ion Monitor
AIR	All-India Rainfall
AOML	Atlantic Oceanic and Meteorological Lab
APDRC	Asia-Pacific Data-Research Center
APE	Adjoint-based Parameter Estimation
AR4	Fourth Assessment Report
ARSHSL	The Archive of Rapidly-Sampled Hawaiian Sea Level
ASM	Asian Summer Monsoon
AT	Archival Tags
AUTODIF	Automatic Differentiation
BAMS	Bulletin of the American Meteorological Association
BET	Bigeye Tuna
BFAL	Black-footed Albatross
BotCam	Bottomfish Camera
CBS	Commission for Basic Systems
CCA	Canonical Correlation Analysis
CEROS	Center for Excellence in Ocean Sciences
CICIMAR	Centro Interdisciplinario De Ciencias Marinas
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
CLIOTOP	Climate Impacts on Oceanic Top Predators
CLIVAR	Climate Variability and Predictability Study
CNMI	Commonwealth of the Northern Mariana Islands
CO	Carbon Monoxide
CO-OPS	Center for Operational Oceanographic Products and Services
CPUE	Catch Per Unit Effort
CRED	Coral Reef Ecosystem Division
CREIOS	Coral Reef Ecosystem Integrated Observing System
CRMI	Coral Reef Management Initiative
CTD	Conductivity, Temperature, Depth Casts
DSCR	Data System Change Request
DSS	Data Server System
EAA	Essential Amino Acids
EEZ	Exclusive Economic Zone
ENSO	El Niño/Southern Oscillation
EPA	Environmental Protection Agency
EPO	Eastern Pacific Ocean
ETP	Eastern Tropical Pacific
EwE	Ecopath with Ecoism
FAD	Fish Aggregation Device
FFA/SPC	Forum Fisheries Agency/South Pacific Communities
FIS	Fisheries Information System
FONSI	Finding of No Significant Environmental Impact
FSWP	Fishery Statistics of the Western Pacific
FUS	Fisheries of the United States
GAM	Generalized Additive Model
GCOS	Global Climate Observing System

GEV	Generalized Extreme Value
GIS	Geographic Information System
GLM	Generalized Linear Model
GLOBEC	Global Ocean Ecosystems Dynamics
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GOES	Geostationary Operational Environmental Satellites
GOOS	Global Ocean Observing System
GPS	Global Positioning System
GTS	Global Telecommunications System
HARP	High Frequency Acoustic Recording Package
HCD	Habitat Conservation Division
HDAR	Hawaii Division of Aquatic Resources
HEA	Habitat Equivalency Analysis
HMRFS	Hawaii Marine Recreational Fishing Survey
HSCO	Hawaii State Climate Office
IATTC	Inter-American Tropical Tuna Commission
IBMs	Individual Based Models
IFP	International Fisheries Program
IMPARPE	Instituto del Mar del Peru
INCOIS	Indian National Centre for Ocean Information Services
INMARSAT	International Maritime Satellite
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated Ocean Observing System
IOTWS	Indian Ocean Tsunami Warning System
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
ISC	International Scientific Committee
ITCZ	Intertropical Convergence Zone
JASMINE	Joint Air-Sea Monsoon Interaction Experiment: Upper Ocean Survey
JIMAR	Joint Institute for Marine & Atmospheric Research
kfSST	Kalman Filter Sea Surface Temperature
LAAL	Laysan Albatross
LF	Low Frequency
LHR	Latent Heat Release
LMR	Living Marine Resources
LODS	Longline Observer Data System
MARDAP	Marine Resource Dynamics and Assessment Program
MARS	Micronesian Archaeological Research Services
MFCL	MULTIFAN-CL
MHI	Main Hawaiian Islands
MLO	Mauna Loa Observatory
MMRP	Marine Mammal Research Program
MPA	Marine Protected Areas
MSY	Maximum Sustainable Yield
MT	Metric Tons
MTRP	Marine Turtle Research Program
MULTIFAN-CL	a length-based, age and spatially-structured statistical model for fisheries stock assessment
NAA	Nonessential Amino Acids
NCDC	National Climate Data Center
ND	November-December
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service

NFA	National Fisheries Authority
NGO	Non Governmental Organization
NIWA	National Institute of Water and Atmospheric Research
NLOM	Navy Layered Ocean Model
NMC	National Meteorological Centers
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NRIFSF	National Research Institute of Far Seas Fisheries
NRL	Navy Research Laboratory
NWHI	Northwestern Hawaiian Islands
NWS	National Weather Service
OCO	Office of Climate Observations
OMB	Office of Management and Budget
PACIS	Pacific Climate and Information Services
PASTA	Pacific-Atlantic Sea Turtle Assessment
PAT	Pop-up Archival Transmitter
PEA	Programmatic Environmental Assessment
PEAC	Pacific ENSO Applications Center
PFEL	Pacific Fisheries Environmental Laboratory
PI	Principle Investigator
p-FAD	Private Fish Aggregation Device
PFRP	Pelagic Fisheries Research Program
PICTs	Pacific Island Countries and Territories
PIFSC	Pacific Islands Fisheries Science Center
PIR	Pacific Islands Region
PIRO	Pacific Islands Regional Office
PIT	Passive Integrated Transponder
PMEL	Pacific Marine Environmental Laboratory
PNG	Papua New Guinea
PRIA	Pacific Remote Island Areas
PRIDE	Pacific Region Integrated Data Enterprise
PRIWG	Pacific Region Interagency Coral Reef Mitigation Working Group
PSAT	Pop-up Satellite Archival Tags
PTT	Platform Terminal Transmitter tag
PTWC	Pacific Tsunami Warning Center
QB	Quasi-Biennial
REA	Rapid Ecological Assessment
RFP	Request for Proposal
ROAM	Regional Ocean-Atmosphere
SAR	Synthetic Aperature Radar
SCTB	Standing Committee on Tuna and Billfish
SEAPODYM	Spatial Ecosystem and Populations Dynamics Model
SEC	South Equatorial Current
SECC	South Equatorial Counter Current
S-EOF	Season-reliant Empirical Orthogonal Function
SFD	Sustainable Fisheries Division
SFI	Sustainable Fisheries Initiative
SLA	Sea Level Anomaly
SODA	Simple Ocean Data Simulation Model Analyses
SOEST	School of Ocean & Earth Science & Technology
SPC	Secretariat of the Pacific Community

SST	Sea Surface Temperature
SWFSC	Southwest Fisheries Science Center
TDRs	Time-Depth-Temperature Recorders
TEDs	Turtle Excluder Devices
THg	Total Mercury
UH	University of Hawaii
UHSLC	University of Hawaii Sea Level Center
ULT	Ultra Low Temperature
UNESCO	United Nations Educational Scientific and Cultural Organization
USAPI	U.S. Affiliated Pacific Islands
USFWS	US Fish and Wildlife Service
VIMS	Virginia Institute of Marine Science
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WCRN	West Coast Regional Node
WCRP	World Climate Research Programme
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorological Organization
WMT	White Muscle Tissue
WOCE/JGOFS	World Ocean Circulation Experiment/Joint Global Ocean Flux Study
WPacFIN	Western Pacific Fisheries Information Network Project
WPFMC	Western Pacific Fisheries Management Council
WPRFMC	Western Pacific Regional Fishery Management Council
WUTMI	Women United in the Marshall Islands
XBT	Expendable Bathythermograph

Appendix II Visiting Scientists

DATE	NAME/AFFILIATION	PURPOSE OF VISIT
07/11/05-07/15/05	Paola Francesca Riolo Department of Marine & Wildlife Resources Pago Pago, American Samoa	Conduct workshop on "Geographic Information Systems for Fisheries"
07/25/05-07/29/05	Raghuram Murtugudde University of Maryland Earth System Science Interdisciplinary Center (ESSIC)	Collaborate with PFRP staff on fishery modeling
08/07/05-08/19/05	Robert Ahrens University of British Columbia (UBC) Fisheries Center	Participant in the Methods Working Group of the Western and Central Pacific Fisheries Commission meeting in Noumea, New Caledonia 08/08/05-08/19/05
08/22/05-08/26/05	Glenn Carter University of Washington Applied Physics Lab	Collaborate with JIMAR's Sea Level Program, attend the IAPSO Dynamic Planet 2005 Conference in Cairns, Australia, present HOME (Hawaii Ocean Mixing Experiment) results including those involving the Sea Level's model work
09/02/05-10/02/05	Qamar Schuyler Coastal Resources Management Office Coral Reef Initiative Saipan	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
09/02/05-10/02/05	Frances Castro CNMI Division of Environmental Quality Saipan	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
09/02/05-10/02/05	Peter Houk CNMI Division of Environmental Quality Saipan	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
09/02/05-10/02/05	Edson Limes Coastal Resources Management Saipan	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
09/02/05-10/02/05	Anthony Flores Saipan Government Division of Fish and Wildlife	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds

09/02/05-10/02/05	Michael Tenorio Saipan Government Division of Fish and Wildlife	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
11/14/05-11/18/05	William John Hampton Secretariat of the Pacific Community Ocean Fisheries Programme	Invited speaker for the Pelagic Fisheries Research Program's Research Priorities Workshop, participant in the PI workshop 11/14/05-11/18/05
11/15/05-11/23/05	Milani Chaloupka Ecological Modeling Services	Participant in the Pelagic Fisheries Research Program's PI meeting to provide expertise in survivorship of sea turtles after their interaction with fisheries 11/14/05-11/15/05
11/16/05-11/18/05	Richard Deriso Inter-American Tropical Tuna Commission	Invited speaker for the Pelagic Fisheries Research Program's Research Priorities Workshop 11/16/05-11/18/05
11/16/05-11/18/05	Ziro Suzuki National Research Institute of Far Seas Fisheries	Invited speaker for the Pelagic Fisheries Research Program's Research Priorities Workshop 11/16/05-11/18/05
11/16/05-11/18/05	Paul Callaghan Western Pacific Fisheries Management Council, Scientific and Statistical Committee	Participant in the Pelagic Fisheries Research Program's Research Priorities Workshop 11/16/05-11/18/05
01/23/06-01/26/06	Sheik Dawood Mohamed Abdool Mauritus Meteorology Agency	Repair tide gauge in Rodrigues, Mauritus
02/07/06-02/12/06	Chin-Hwa Sun Institute of Applied Economics (IAE) Taiwan	Discuss potential research collaboration between JIMAR and Institute of Applied Economics in National Taiwan Ocean University
02/09/06-03/13/06	Victoria Okimura Washington State Department of Fish & Wildlife Marine Resource Division	Participant in cruise OES-05-11 aboard NOAA Vessel Oscar Elton Sette within American Samoa fishing grounds
02/19/06-02/22/06	Jianglong Zhang UCAR Naval Research Laboratory Monterey, CA	Interview with the Department of Meteorology in connection with an application for faculty position

03/01/06-03/05/06	Vaughan Phillips Princeton University Princeton, NJ	Interview with JIMAR and the Department of Meteorology in connection with an application for faculty position
03/16/06-03/21/06	Sheik Dawood Mohamed Abdool Mauritus Meteorology Agency	Repair tide gauge in Rodrigues, Mauritus (part of repair job done 01/23/06-01/26/06)
04/10/06-04/28/06	Jeffrey Graham Scripps Institution of Oceanography	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/11/06-04/15/06	Chris Bretherton University of Washington Atmospheric Sciences & Applied Math Seattle, WA	Collaborate with Yuqing Wang, Shang-Ping Xie, and other IPRC members on study of eastern Pacific climate
04/11/06-05/05/06	Gregor Cailliet Moss Landing Marine Laboratories	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/12/06-04/14/06	Itaru Ohta Okinawa Prefectural Fisheries and Ocean Research Center, Ishigaki Lab Okinawa, Japan	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/15/06	Paul Durrenberger Penn State	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/15/06-04/18/06	Andrew Pershing Cornell University Ithaca, NY	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/18/06-04/21/06	Jie Shi Ocean University of China Key Lab of Oceanography P.R. China	Poster presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06
04/19/06-04/21/06	Alexei Pinchuk University of Alaska Fairbanks School of Ocean Sciences	Poster presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06
04/19/06-04/21/06	Jaime Jahncke PRBO Conservation Science Marine Ecology Division	Poster presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06

04/19/06-04/21/06	Takuya Nakanowatari Hokkaido University Institute of Low Temperature Science	Poster presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06
04/19/06-04/21/06	Hyun Ju Seo Pukyong National Unviersity Department of Meteorology	Poster presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06
04/19/06-04/21/06	Eun Jung Kim Pukyong National University Department of Marine Biology Korea	Presentation at the GLOBEC/PICES symposium 04/19/06-04/21/06
04/20/06	Bruno Leroy Secretariat of the Pacific Community New Caledonia	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/24/06	Bruce Robison MBARI	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/25/06-04/27/06	John Musick VIMS	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/25/06-05/08/06	Donald Olson University of Miami	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/27/06	Erwan Josse Institut de Recherche pour le Developpement	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/27/06	Timothy Miller Large Pelagics Research Center	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/28/06	Andre Punt University of Washington	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
04/30/06	Daniel Huppert University of Washington	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration

05/01/06	Seth Newsome Carnegie Geophysical Lab	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/01/06	R. Michael Laurs RML Fisheries Oceanographer Consultant, LLC Jacksonville, OR	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/02/06-05/12/06	Charlotte Girard Collecte Localisation Satellite (CLS) Division of Oceanographic Spatiale France	Add and edit computerized tagging data collected for the PFRP Tagging Data Repository
05/04/06	Ronald O'Dor Consortium for Oceanographic Research & Education (CORE)	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/04/06	Ralph Townsend University of Maine	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Peter Bushnell Indiana University South Bend Department of Biology	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Jerald Ault University of Miami RSMAS	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Robert Hueter Mote Marine Laboratory Sarasota, FL	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Arthur Miller UCSD SIO	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Bonnie McCay Merritt Rutgers University	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration
05/05/06	Dawn Parker George Mason University	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration

05/10/06-05/12/06	Maria Ortiz De Zarate Instituto Espanol Oceanografia (IEO) Spain	Review proposal submitted to the JIMAR Pelagic Fisheries Research Program Steering Committee for funding consideration

Appendix III Seminar List

DATE	NAME/AFFILIATION	PURPOSE OF VISIT/TITLE
7/11/05-7/15/05	Paola Francesca Riola Department of Marine & Wildlife Resources Pago Pago, American Samoa	Conduct workshop on "Geographic Information Systems for Fisheries" and present seminars discussing GIS research
7/27/05	Raghuram Murtugudde University of Maryland, Earth System Science Interdisciplinary Center (ESSIC)	Participant in the collaborative JIMAR-IPRC seminar on "Modeling the distribution of pelagic animals"
2/07/06-2/12/06	Chin-Hwa Sun Institute of Applied Economics (IAE) Taiwan	"Fishing Capacity Management Policy of Distant Water Tuna Longline Fisheries and Evaluation of the Vessel Buyback Program in Taiwan"
2/15/06	John Lyman Seattle, WA	"Tropical Instability Waves in the Tropical Atmosphere Ocean Array" Pacific Marine Environmental Laboratory/JIMAR

Appendix IV Workshops and Meetings Hosted By JIMAR

Pelagic Fisheries Research Program Principal Investigators Workshop
November 14-18, 2005

Ajtai, Peter

Allain, Valerie

Allen, Stewart

Amesbury, Judith

Bartlett, Nicole

Bartram, Paul K.

Bigelow, Keith

Bisson, Jeremy

Boggs, Christofer

Cai, Junning

Callaghan, Paul

Chaloupka, Milani

Cooper, Patricia

Dagorn, Laurent

Dalzell, Paul

Deriso, Richard B.

Domokos, Reka

Drazen, Jeff

Duffy, David

Fragoso, Nuno

Fry, Brian

Galvan-Magaña, Felipe

Glazier, Ed

Gough, Amy

Griesemer, Adam

Grubbs, Dean

Hamilton, Marcia

Hampton, John

Hawn, Donald

Hebshi, Aaron

Heppell, Selina

Hinton, Michael

Holland, Kim

Howell, Evan

Itano, David

Graham, Brittany

Kaneko, John

Kirby, David

Kleiber, Pierre

Krasnick, George

Lehodey, Patrick

Li, Shichao

Long, Amy

Martin, Sean

Maunder, Mark

Maury, Olivier

McCarthy, Abigail

McCreary, Scott

McNaughton, Blake

Ming, Timothy

Miyamoto, Earl

Morioka, Roy

Muir, Jeff

Myer, Carl

Nguyen, Quang

Nielsen, Anders

Olson, Robert

Pan, Minling

Polovina, Jeffrey

Poncelet, Eric

Pooley, Sam

Popp, Brian

Pradhan, Naresh

Richards, Kelvin

Seki, Michael

Senina, Inna

Severance, Craig J.

Sibert, John

Simonds, Kitty

Skillman, Robert

Snover, Melissa

Suzuki, Ziro

Turner, Jason

Walsh, William A.

Wilcox, Chris

Johnoel Ancheta

Dodie Lau

Appendix V JIMAR Personnel

Information as of June 30, 2006

Category	Number	Unknown	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	16	0	0	0	0	1	15
Visiting Scientist	4	0	0	0	0	0	4
Postdoctoral Fellow	10	0	0	0	0	0	10
Research Support Staff	93	0	2	4	53	28	6
Administrative	17	0	2	0	14	1	0
Undergraduate Students	26	0	26	0	0	0	0
Graduate Students*	19	0	0	0	10	8	1
Received less than 50% NOAA support	18	0	0	1	5	1	11
Total	**203**	**0**	**30**	**5**	**82**	**39**	**47**
Located at Lab (include name of lab)	PMEL = 3 PFEL = 8 PIRO = 19 PIFSC = 95 CMDL = 4 NWS = 1						
Obtained NOAA employment within the last year	5						
Postdoctoral Fellows and Students from Subgrantees	24						

*One graduate student pursuing another Ph.D. degree.

Appendix VI 2006 Awards

2006 Awards

David Foley
RCUH Employee of the Year Finalist

Yonat Swimmer
Fullbright Award to include this aspect of the work in her research and teaching in Brazil.

Brittany Graham
4th International Billfish Symposium Travel Grant Award
UH Graduate Student Organization (GSO) Travel/Research Award

Sociological Baseline of Hawaii Longline Industry Project
Best Paper Award, Policy Research (2nd Place), NOAA Fisheries Social Scientist Conference, San Francisco, CA, April 2006. Paper by Stewart Allen and Amy Gough was on Vietnamese-American longline fisherman's adaption to fisheries regulation.

Appendix VII Publication Summary

The table below shows the total count of publications for the reporting period and previous periods categorized by NOAA lead author or institute (or subgrantee) lead author and whether it was peer-reviewed or non-peer-reviewed.

	JI Lead Author					NOAA Lead Author					Other Lead Author				
	FY02	FY03	FY04	FY05	FY06	FY02	FY03	FY04	FY05	FY06	FY02	FY03	FY04	FY05	FY06
Peer - Reviewed	19	18	36	50	36	7	33	22	26	20	17	20	30	26	28
Non-Peer-Reviewed	15	16	39	31	24	15	10	17	14	16	10	14	21	17	17