2004 Annual Report
for Cooperative Agreement NA17RJ1230

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Annual Report
for
Fiscal Year 2004

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Introduction

Thomas Schroeder
Director

The Joint Institute for Marine and Atmospheric Research (JIMAR) was created in 1977 through a Memorandum of Understanding between the National Oceanic and Atmospheric Administration (NOAA) and the University of Hawaii at Manoa. JIMAR is part of the School of Ocean and Earth Science and Technology. The mission of JIMAR is to conduct research of mutual interest to NOAA and the University. JIMAR works closely with the Environmental Research Laboratories of NOAA as well as the National Weather Service through its Pacific Region and the National Marine Fisheries Service (NMFS) through the Pacific Islands Fisheries Science Center. The principal research themes of JIMAR are:

1. Equatorial oceanography,
2. Tsunamis and other long-period waves,
3. Climate,
4. Fisheries oceanography,
5. Tropical meteorology, and
6. Coastal research.

Coastal Research became a new theme with the approval of the 2001-2006 cooperative agreement. FY 2002 was the first-year of the new agreement. The charts on the following page show the distribution of JIMAR's funding by tasks and themes under the current cooperative agreement to date.

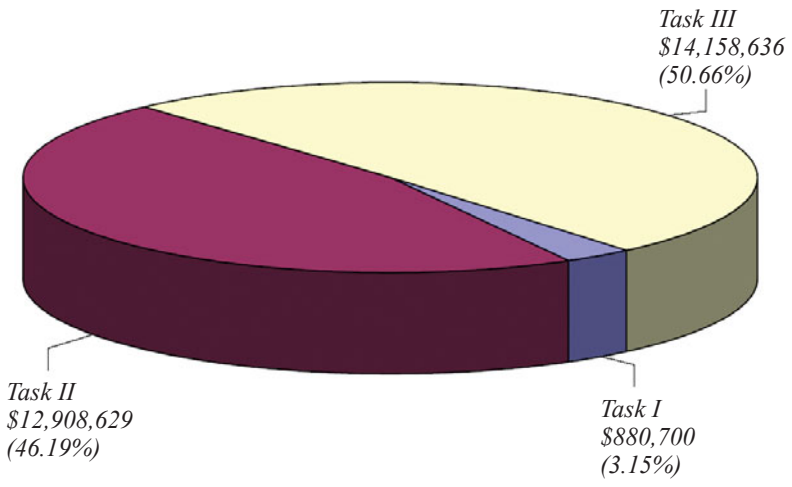
FY 2004 was highlighted by the formal review of JIMAR conducted for the first time under the auspices of the NOAA Science Advisory Board (SAB). The review was held in March, and the final report of the review panel was accepted by the SAB at its July 2004 meeting. The report contained a number of constructive suggestions on JIMAR administration and science planning. We are moving to implement as many of these as possible. In the course of the evolution of the SAB review process, it was determined that participation of a Joint Institute Director on the review panels provided useful context on the nature of Joint Institutes. In this capacity, the JIMAR Director participated in the reviews of the Cooperative Institute for Research in the Atmosphere (CIRA) in November 2003 and the Cooperative Institute for Arctic Research (CIFAR) in June 2004.

Fisheries research has continued to expand in concert with the development of the new Pacific Islands Region. The Pelagic Fisheries Research Program (PFRP) presented a 10-year report to Congress describing a decade of accomplishments in fisheries science. In the spring of 2004, the Hawaii longline fishery was re-opened, primarily as a result of new techniques developed through a collaboration between NMFS and JIMAR. Development of the graduate program in Tropical Fisheries and Aquaculture (a joint venture of NMFS, PFRP, and the School of Ocean and Earth Science and Technology) has continued.

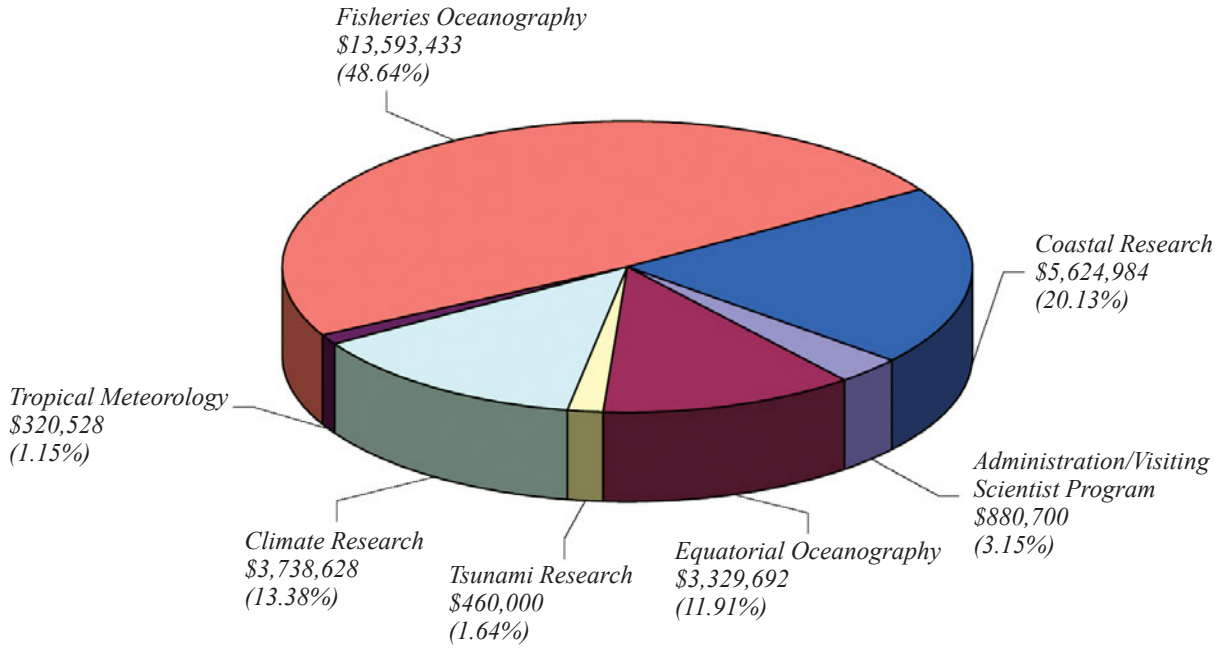
JIMAR has worked closely with the regional oceanography community to develop Hawaii's entry into the regional ocean observing system initiative. This program is embedded within the national Integrated Ocean Observing System (IOOS) program. The excellence of JIMAR oceanography continues to be recognized. Emeritus Professor of Oceanography and JIMAR Senior Fellow, Klaus Wyrtki, received the Alexander Agassiz Medal from of the National Academy of Sciences. An additional highlight in our Equatorial Oceanography/Climate themes was the acceptance by the *Journal of Physical Oceanography* of a paper whose lead author is an undergraduate employee; two co-authors are Senior Fellows.

For the first time since 1998, the Pacific ENSO Applications Center (PEAC) is fully-staffed through the addition of a research scientist and a NOAA Commissioned Corps Officer as an outreach officer. This has been timely, as the late summer of 2004 has been declared a weak El Nino for the central Pacific. As this report goes to press, we are inaugurating our first cooperative venture with the Mauna Loa Observatory (MLO), a facility managed by NOAA's Climate Monitoring and Diagnostics Laboratory. MLO, located on the island of Hawaii, is renowned for its long-term atmospheric monitoring program, highlighted by its 47-year time series of atmospheric carbon dioxide concentrations.

Distribution of JIMAR's NOAA Funding by Task



Distribution of JIMAR's NOAA Funding by Theme



ACCOMPLISHMENTS FOR FISCAL YEAR 2004

Equatorial Oceanography

The University of Hawaii Sea Level Center

P.I.: Mark Merrifield

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 University of Hawaii Sea Level Center (UHSLC) is engaged in sea level research based largely on direct in situ measurements at tide gauge stations. The UHSLC works with various international agencies to ensure that tide gauge data are collected over a globally distributed network, that all data are readily available to the research and operational oceanography communities, and that the data are quality controlled in a user-friendly format. The UHSLC also seeks to incorporate geodetic measurements of land motion at tide gauge sites in support of absolute sea level investigations.

Progress During FY 2004

The UHSLC operates 38 tide gauge stations in the global sea level network. The historical data return for the UHSLC network is 93.8%, the current year's return is 95.3%, and the previous year's return was 96.8%. The center maintains a fast delivery database (141 stations, data latency: 1 month) in support of various national and international programs (e.g., CLIVAR, GLOSS). The fast delivery data are used for monitoring the altimeter drift, in particular the JASON altimeter, and the ties between various altimeter missions. We are near completion of a quasi-real time dataset (data latency: 1 day) in support of GODAE and national and international observing systems. Approximately 50 stations currently are available in real-time with plans for ongoing expansion. We are working on developing a netCDF format for our various databases and will also make all data available to the National Oceanographic Partnership Program's National Virtual Ocean Data System, the NOAA Observing System Architecture (NOSA) geospatial and geospatial metadata databases, the Climate Data Portal, and other emerging data portals.

Interannual and decadal changes and sea level rise have been our primary research focus areas during FY2004. A manuscript describing decadal oscillations in sea level in the eastern Pacific has been accepted by the *Journal of Physical Oceanography*. A study of island sinking rates along the Hawaiian island chain formed the basis for a student Masters thesis and an article submitted to *Geophysical Research Letters*. We are extending this analysis to consider differential GPS rates at tide gauges throughout the Pacific. We are continuing our study, in collaboration with the National Tidal Facility (NTF), of a case history of sea level data collection at the Funafuti atoll in Tuvalu. This paper documents how a consistent high quality time series that is useful for climate studies is collected and managed. The island of Hawaii experienced one of the highest sea level events on record during the latter part of 2003. Flooding of low-lying coastal areas and enhanced beach erosion throughout the State were attributed to this event. We are in the progress of completing a paper describing how eddies that travel across the eastern Pacific play a major role in establishing these month-long anomalies.

Names of Students Graduating with M.S. or Ph.D. Degrees During FY 2004

Dana Caccamise, M.S.

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 Goal(s)

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

Purpose of the Project

There are two objectives: 1) 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, and 2) to estimate the penetration and inventory of anthropogenic CO_2 in the ocean, using variable remineralization ratios.

Progress During FY 2004

We have finished the calculation to obtain the remineralization ratios in the Indian Ocean. The results confirm the conclusion obtained earlier for deep waters, but the remineralization ratios for the shallower waters are definitely different. The loss of nitrogen during the nitrification and denitrification processes in the Indian Ocean is significant.

Tsunami Research

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

P.I.: Douglas S. Luther

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 sea level observations from existing Hawaiian shoreline gauges maintained by NOAA agencies. This sea level dataset is publicly available via a web site on the Internet. For research purposes, the dataset is maintained for investigations into the dynamics of ocean phenomena such as infragravity waves (1-10 minute periods), tsunamis (1 to 60 minute periods), 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. 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 the study of the variety of phenomena listed above, and especially ensures that even the data containing weak tsunami signals is archived in a consistent manner.

Progress During FY 2004

The Archive of Rapidly-Sampled Hawaiian Sea Level (ARSHSL) is being maintained on the World Wide Web (new WWW address for 2004: http://www.soest.hawaii.edu/oceanography/dluther/arshsl.html) by K. Bartlett and M. Luther, in collaboration with the UH Sea Level Center. Data are automatically and, if necessary, manually downloaded daily, via Internet and telephone links, from 6 NOS and 15 PTWC gauges dispersed around the five main islands of Hawaii (this represents no change from our last report in 2003). The data, as originally sampled at 1, 60, 120, or 360 second intervals, are stored on the ARSHSL web site after both a quality control check and, in most cases, elimination of extreme outliers. Access to the web site is unrestricted, e.g., five new users in the past year have downloaded data from the archive, including graduate students, government civil engineers, and even PTWC. The applications 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.

Maintenance of the archive continues to be plagued by gauge failures and network interruptions beyond our control. As problems have developed with individual gauges, we have provided diagnostic information to PTWC or NOS, as appropriate, in order to promote maintenance activities. PTWC and NOS personnel are always helpful and grateful for our advisories, but lack of resources has sometimes meant long delays in repairing broken gauges. This problem remains a deterrent to maximizing the archive's data holdings. We have decided to mitigate the impact of network interruptions by eliminating any communication to the sea level gauges via outer island computers and modems. This change of philosophy was facilitated by the dramatic reduction of inter-island telephone call rates from $0.10/min to $0.03/min, so that the cost of long distance phone calls to download the data is about the same now as it is to maintain the outer island modems and computers, which require frequent attention due to power outages, hacker attacks and so forth.

Climate Research

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

P.I.: Thomas A. Schroeder

NOAA Goal(s)

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

Purpose of the Project

Nearly ten years ago the NOAA Office of Global Programs (OGP) funded the establishment of the Pacific ENSO Applications Center (PEAC). PEAC is a cooperative effort among the National Weather Service Pacific Region (NWSPR), the University of Hawaii (UH), the University of Guam (UOG) and the Pacific Basin Development Council (PBDC). The NOAA Corps and OGP provided initial staffing for the Center. PEAC has cooperated with UH and the NOAA/National Center for Environmental Predictions (NCEP)/Climate Prediction Center (CPC) in research on experimental climate prediction. Social scientists at UH, UOG, PBDC and, recently, the East-West Center conduct research on impacts of interannual climate variability on the economics, cultures, and public health of the U.S.-affiliated Pacific Islands.

Progress During FY 2004

For the first time since 1997, PEAC is fully staffed. A NOAA Corps officer is now on site in an outreach function. An applications scientist arrived in November 2003 and has implemented new studies of experimental sea level prediction. Routine operations in the form of issuance of quarterly newsletters and maintenance of a website which contains climatological data, research results and newsletter texts have continued.

In June 2004 a special workshop (PEAC Regional Workshop) was held at the East-West Center. Participants were presented a number of success stories demonstrating the effective use of PEAC forecast products to manage climate risks in several sectors including water resource management, with direct benefits to Pacific Island Communities as well as secondary benefits such as fisheries and tourism; power and utilities; and emergency management. Workshop participants offered a number of specific recommendations in the context of those PEAC program characteristics that were identified as keys to PEAC's successful first decade and provided a number of recommendations on strengthening the PEAC product line.

Names of Students Graduating with M.S. or Ph.D. Degrees During FY 2004

Rebecca Schneider, M.S.

Effects of the Andes on the Eastern Pacific Climate

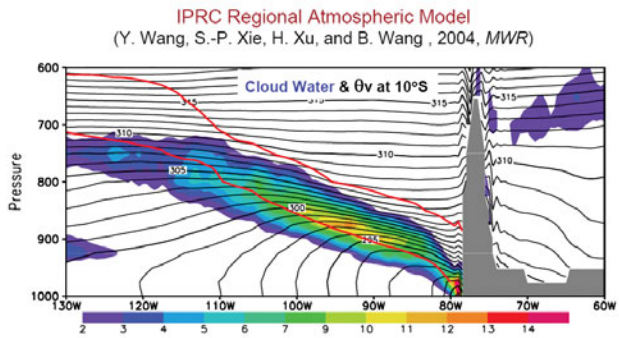
P.I.: Shang-Ping Xie and Yuqing Wang

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.



Stratus cloud deck simulated by the IPRC regional atmospheric model. Cloud liquid water (color), virtual potential temperature (black contours), and temperature inversion layer enclosed by red lines. South American mountains are shaded in gray. From Wang et al. (2004a).

Progress During FY 2004

We have carried out research in three areas. 1) A high-resolution numerical model is used to examine the atmospheric boundary layer adjustment to the sharp North Equatorial Front and the results suggest that the pressure gradient plays an important role. 2) Experiments using the International Pacific Research Center (IPRC) regional atmospheric model show that boundary layer clouds over the Southeast Pacific exert a significant influence on large-scale atmosphere circulation through their radiative effect. Analysis of new satellite observations reveal pronounced subseasonal variability in the Southeast Pacific stratus deck, in association with advection of cold air up the SST gradient. 3) New satellite observations reveal a clear effect of an ocean thermocline dome on summer precipitation in the eastern Pacific Intertropical Convergence Zone. The thermocline dome itself is an ocean response to intense wind jets through Central American mountain gaps. Finally, the P.I. has several review papers.

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

P.I.: Shang-Ping Xie

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 2004

We have conducted two major studies. In one, we investigated the mechanisms for the annual cycle in wind over the equatorial Atlantic. The cross-equatorial wind cycle is dominated by the effect of West African monsoon, featuring an abrupt acceleration of southerlies in the Gulf of Guinea toward West Africa. The zonal wind annual cycle causes the upwelling on the equator and shoals the thermocline in the Gulf of Guinea in June-July. The easterly acceleration of equatorial wind is caused by differing mechanisms in the western and eastern basins: by interaction with the developing cold tongue, and by the equatorward advection of easterly momentum from the subtropical South Pacific, respectively.

The second study reveals an overlooked seasonal cooling in the equatorial Atlantic in November-December. This secondary cooling (relative to the major cooling in June-August) is not well captured in some widely used climatologies because of poor temporal resolution but is confirmed in five-year moored buoy measurements. Interestingly, interannual sea surface temperature (SST) variance displays a maximum in months when this secondary seasonal cooling takes place presumably because of the shoaling thermocline.

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

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

NOAA Goal(s)

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

Purpose of the Project

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 fieldwork 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 ocean component (UH) had three specific goals: to document the meridional structure of temperature, salinity and velocity as they vary during active and break periods of the monsoon; to quantify the mixed layer and barrier layer structures in the Bay of Bengal sector; and to estimate upper ocean budgets of heat, freshwater and momentum. An overarching purpose was to obtain a comprehensive data set during the summer monsoon for the evaluation and improvement of ocean and coupled air-sea models.

Progress During FY 2004

As the project nears completion, the observations are being used to guide model studies with our collaborators in accord with our plans for this stage of the project. During the past year, the primary focus of our work has been the publication of a paper on the importance of atmospheric intraseasonal variability for driving the upper ocean circulation in the Indian Ocean and the resulting low-frequency rectification of equatorial surface currents and transport. In addition, JASMINE data have been used to help plan a program of sustained observations (including NOAA/PMEL participation) and future process studies in the Bay of Bengal sector of the Indian Ocean in the Climate Variability and Predictability Program (CLIVAR) context.

Establishment of a Data and Research Center for Climate Studies

P.I.: Julian P. McCreary, Jr., Peter Hacker, Ron Merrill, Humio Mitsudera, and Takuji Waseda

NOAA Goal(s)

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

Purpose of the Project

The project continues the establishment and operation of the Asia-Pacific Data-Research Center (APDRC) within the International Pacific Research Center (IPRC) at the University of Hawaii. 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 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. The project is a collaborative effort with NOAA/PMEL and NOAA/Geophysical Fluid Dynamics Laboratory (GFDL) to implement infrastructure in support of the Global Ocean Data Assimilation Experiment (GODAE).

Progress During FY 2004

The project continued work addressing the four major activities at the APDRC: operation and further development of the Data Server System (DSS); build towards a global data archive for climate studies and the necessary data management; conduct value-added activities that produce needed data products; and coordinate and collaborate with our national and international partners on the implementation of a distributed and linked climate data server network. We have expanded 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 serving (in near-real-time) the global Navy Research Laboratory Layered Ocean Model (NLOM) output for the past 1.5 years. Utilizing NOAA/PMEL's substantial expertise, the project has collaborated closely with PMEL on technical server development activities. In addition, the project has collaborated closely with Japan on server development and

on data and product distribution. In collaboration with NOAA/GFDL activities and in support of GODAE, the APDRC has expanded data quality control activities related to historical ocean profile data through partnerships with the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and the Woods Hole Oceanographic Institution; and have begun activities in support of a linked, Pacific regional data center for delayed-mode Argo float data with the Japan Agency for Marine Earth Science and Technology (JAMSTEC) in Japan. To enhance user access to our web-based data and product servers, we have also implemented a major upgrade to our homepage at http://apdrc.soest.hawaii.edu.

Remote Forcing on the Warm Season Rainfall of North America and Eastern Pacific Climate

P.I.: Bin Wang

NOAA Goal(s)

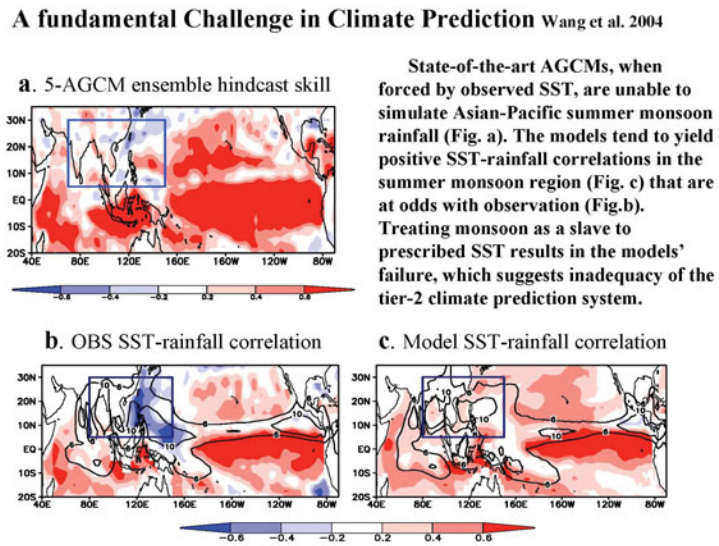
- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The objectives of our previous PACS project are to determine how continental monsoons affect the mean climate and seasonal cycle of the eastern Pacific and physical processes that link U.S. warm season rainfall anomalies and the western Pacific anomalies.

Progress During FY 2004

The above objectives have been fulfilled very well. We have completed four papers that directly address the eastern Pacific climate and U.S. warm season rainfall variability. In addition, we have moved into a coupled model of the Pacific climate and monsoon intraseasonal Oscillation.



In a recently submitted paper, we proposed a fundamental challenge to the scientific basis of the seasonal climate prediction. The scientific basis for climate prediction lies in the climate systems' predictability determined by variations of the ocean and land surface conditions. Here we show that the state-of-the-art atmospheric general circulation models (AGCMs), when forced by observed sea surface temperature (SST), are unable to simulate with any accuracy Asian-Pacific summer monsoon rainfall. The models tend to yield positive SST-rainfall correlations in the summer monsoon that are at odds with observations. The observed lead-lag correlations between SST and rainfall suggest that the treating monsoon as a slave to prescribed SST results in the models' failure. We demonstrate that an AGCM, coupled with an ocean model, simulated realistic SST-rainfall relationships; however, the same AGCM fails when forced by the same SSTs that are generated in its coupled run. Neglect of atmospheric feedback makes the forced solution depart from the coupled solution in the presence of initial noises or tiny errors in the lower boundary. This suggests that the coupled ocean-atmosphere processes are extremely important in the heavy precipitating monsoon convergence zones where the atmospheric feedback to SST is essential. The present finding calls for reshaping of current strategies for predicting monsoon climate and validating AGCMs. The traditional notion that climate can be predicted by prescribing the lower boundary (Tier 2 approach) where AGCM is forced by pre-forecasted SST is inadequate for predicting summer monsoon rainfall, especially in the Asian-Pacific region.

Names of Students Graduating with M.S. or Ph.D. Degrees During FY 2004

Zhuo Wang, Ph.D.

Qinghua Ding, M.S.

Impacts of Warm Pool and Extratropics on ENSO

P.I.: Bin Wang

NOAA Goal(s)

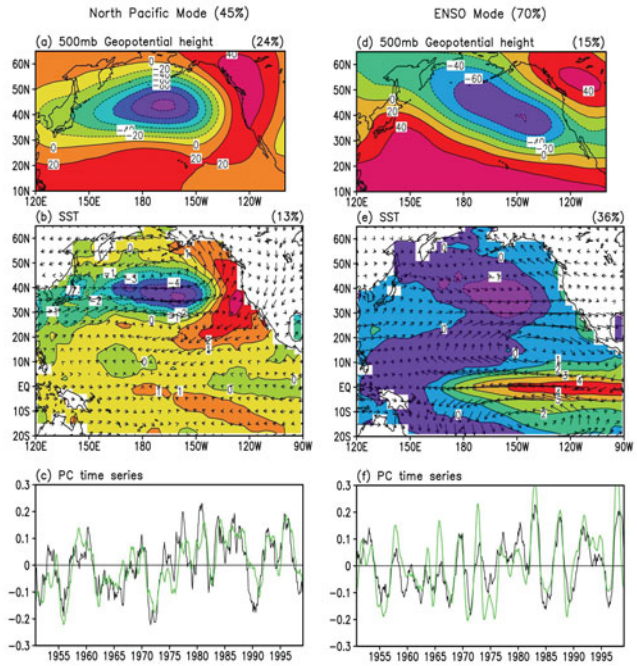
- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

The purposes of this project are to address 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.

Progress During FY 2004

This project is new and just started in October 2003. It is a continuation of our previous Pacific project. Thus far, we have submitted three papers, including contributions from the previous Pacific project. Two manuscripts are in preparation; one discusses TBO and the other deals with multi-time scale of ENSO characteristics.



Distributions of the first CMCA (Conditional Maximum Covariance Analysis) mode associated with (a) 500mb geopotential height, (b) SST, and (c) the corresponding PC time series associated with SST (green line) and 500mb height (black line), when ENSO signals are removed. (d) – (f) as in (a) – (c), but the North Pacific mode's signals are removed. The covariance (the percentage ratio of the covariance explained by a pair of the eigenvectors to the total covariance between two fields) and variance fractions (the percentage ratio of the variance explained by the first eigenvector to the total variance) of are indicated in the upper right-hand corner of each map. Linear regressions of 200mb winds against the PC time series of North Pacific and ENSO modes are overlapped over each SST pattern.

In a recently submitted paper, we have investigated the differences between the externally forced and intrinsic interdecadal modes in the North Pacific by using the conditional maximum covariance analysis. We investigated the coherent patterns between the tropical and North Pacific SST and the North Pacific 500 hPa geopotential height anomalies. Two leading modes are identified. One is an intrinsic mid-latitude mode, the North Pacific (NP) mode, for which SST anomalies are mainly confined to the extratropical North Pacific. The other is a tropical ocean-atmosphere coupled mode, the ENSO mode, in which an ENSO-like SST pattern dominates the tropics; but extratropical SST anomalies are relatively weak. The NP and ENSO modes exhibit distinct spatial and temporal characteristics. For the NP mode, atmospheric variation leads changes in SST, while for the ENSO mode, the opposite is true. The NP mode displays a persistence barrier during August-September, whereas the ENSO mode has a March-April persistence barrier. The upper-tropospheric jet stream associated with the NP and ENSO modes intensifies, respectively, over the central North Pacific and the subtropical northeastern Pacific; consequently, the transient activities maximize in their corresponding jet exit regions. The expansion coefficients of the 500 hPa geopotential height associated with the two modes appear to be significantly correlated. However, by reducing the high-frequency part in expansion coefficients, the correlation becomes insignificant, indicating that the significant correlation results from high-frequency signals that are unrelated to the corresponding SST variation. Our results suggest that the intrinsic coupled mode in the mid-latitude North Pacific may be distinguished from the forced mode by remote ENSO, especially on the interannual time scale.

Profiling CTD Float Array Implementation, Delayed-Mode Salinity Adjustments, and Ocean Climate Research

P.I.: Thomas A. Schroeder [Gregory C. Johnson]

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

JIMAR works with U.S. and International Argo Project partners, especially NOAA/PMEL, 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.

Progress During FY 2004

By working with PMEL to test, deploy, and monitor the engineering data reported from 31 floats in FY 2004, the stated goals for fieldwork were met. This program started with no previous float expertise or infrastructure, meaning that a laboratory had to be equipped, software developed, float testing procedures established, deployment arrangements made, data and metadata exchanged with national and international Argo partners, and so on. This year we learned a lot about how the floats operate, some of their potential failure modes, and how to detect and repair some of these failures. The result of a 100% data return to date is an excellent one.

Progress in the delayed-mode salinity quality control portion of the project included designing and implementing delayed-mode quality control pathways for Argo, refinement of the salinity drift calibration system, incorporation of new regional data into the system, and running all the Scripps Institution of Oceanography float data through the system. The arduous process of creating and agreeing upon various Argo data stream formalisms resulted in some slippage in terms of delayed-mode salinity quality control of U.S. float data (Woods Hole Oceanographic Institution [WHOI] float data are being worked on, and University of Washington [UW], and PMEL data quality control are pending). For climate investigations, a manuscript on the South Pacific Eastern Subtropical Mode water was published, and a regional (South Indian Ocean) Argo database was assembled and quality controlled to allow for description of intermediate water mass properties. The mode water is important in subtropical cells that are hypothesized to be important in decadal modulation of ENSO. In some models intermediate water mass properties are sensitive indicators of anthropogenic climate variability.

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

P.I.: H. Annamalai

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 2004

We have made substantial progress in diagnostics with observational and NCEP-NCAR reanalysis products, and conducting sensitivity experiments with the ECHAM5 Atmospheric General Circulation Model (AGCM), and experiments with a simple linear atmospheric model to address the role of Indo-Pacific warm pool in modulating the ENSO-monsoon relationship and in influencing the amplitude of developing El Niño. Major results of the studies were presented by the P.I. to the CLIVAR Asian-Australian Monsoon Panel Meeting at Pune, India, in February 2004 and are highlighted below.

(1) Impact of Indian Ocean Sea Surface Temperature (SST) anomalies on developing El Niño (Annamalai et al., 2004, *J. Climate*, in press)

Prior to the 1976–77 climate shift (1950–76), SST anomalies in the tropical Indian Ocean consisted of a basin-wide warming during boreal fall of the developing phase of most El Niños; whereas, after the shift (1977–99) they had an east-west asymmetry, a consequence of El Niño being associated with the Indian Ocean Dipole/Zonal Mode (IODZM). In this study, we investigate the possible impact of these contrasting SST patterns on the on-going El Niño, using atmospheric reanalysis products and solutions to both an AGCM and a simple atmospheric model (Linear Baroclinic Model [LBM]), the latter used to identify basic processes. A suite of AGCM experiments, each consisting of a 10-member ensemble, is carried out to assess the relative importance of remote (Pacific) versus local (Indian Ocean) SST anomalies in determining precipitation anomalies over the equatorial Indian Ocean. Solutions indicate that prior to the climate shift, the basin-wide Indian-Ocean SST anomalies generate an atmospheric Kelvin wave associated with easterly flow over the equatorial western-central Pacific, thereby weakening the westerly anomalies associated with the developing El Niño. In contrast, after the shift the east-west contrast in Indian-Ocean SST anomalies does not generate a significant Kelvin-wave response, and there is little effect on the El Niño-induced westerlies. The LBM solutions confirm the AGCM's results. Thus, we conclude that the amplitude of developing El Niño is weakened (strengthened) by the warm pool SST anomalies during PRE76 (POST76).

(2) Response of the ASM to changes in ENSO properties (Annamalai and Liu, 2004, *Quart. J. Roy. Met. Soc.*, accepted)

Diagnostics from observed precipitation and NCEP-NCAR reanalysis products reveal that after the 1976-77 climate shift in the Pacific there was a dramatic change in the response of the Indian Summer Monsoon (ISM) to El Niño, particularly during July-August. Based on 1950-1975 (PRE76) and 1977-2001 (POST76) El Niño composites, we note that the ISM was weaker than normal during the entire monsoon season during PRE76 but only during the onset and withdrawal phases in POST76 period. The major difference between the two epochs, in terms of observed SST during July-August, is the presence of cold SST anomalies over the Indo-Pacific warm pool in POST76. Its effect on the ISM is investigated from a suite of experiments with an Atmospheric General Circulation Model (AGCM).

Using the AGCM, 10-member ensemble simulations, separately for PRE76 and POST76 El Niño events, and cases where SST anomalies inserted over (i) tropical Indo-Pacific-TIP, (ii) tropical Pacific only-TPO, and (iii) tropical Indian Ocean only-TIO, are conducted. Qualitatively, TPO solutions reproduce the observed monsoon response in both epochs. Specifically, during July-August of POST76, the cold SST anomalies in conjunction with remote subsidence suppress the precipitation (3-5 mm/day) over the Maritime Continent-equatorial central Indian Ocean. Inclusion of Indian Ocean SST anomalies in the TIP runs further amplifies the negative precipitation anomalies. The low-level anticyclonic circulation anomalies that develop as a Rossby wave response to these convective anomalies increase the southwesterlies over the northern Indian Ocean to favor a stronger ISM. During PRE76, absence of such cold SST anomalies over the warm pool reinforces El Niño's suppressing effect on the ISM. It is argued that all aspects of SST over the tropical Indo-Pacific need to be considered for understanding the ENSO-monsoon linkage.

(3) Role of the Indian Ocean in Regional Climate Variability - Review Paper (Annamalai and Murtugudde, 2004, *Earth Climate*, The Ocean-Atmosphere Interaction, AGU Monograph, pp. 213-246)

The lead P.I. and the co-P.I., Dr. R. Murtugudde, authored a review paper, "Role of Indian Ocean SST on regional climate variability." The review highlights the past and recent works on the role of Indian Ocean SST on the Asian-Australian monsoon (AAM) variability. The review stresses the importance of accurate measurement of SST over the tropical Indian Ocean for better monitoring the subseasonal and interannual variability of the AAM system.

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 climate theme) and establishment of the Pacific Training Desk.

NWS Pacific International Training Desk

P.I.: Thomas A. Schroeder

NOAA Goal(s)

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

Purpose of the Project

The Pacific International Training Desk provides training in modern meteorological techniques for meteorologists from the World Meteorological Organization Regional Association 5. Trainees are stationed at the NWS Honolulu Forecast Office which is co-located with the UH Department of Meteorology and the Pacific ENSO Applications Center (PEAC). Trainees are exposed to modern analysis and forecast techniques as well as the research environment of JIMAR and UH. Upon conclusion of their time in Honolulu, the trainees return to their country with modern equipment (provided by NWS) as well as some introduction to research, which they can apply to their national service.

Progress During FY 2004

The operation continues at a steady state.

Compilation, Digitization, and Use of Hawaii State Rainfall Records

P.I.: Pao-Shin Chu

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, School of Ocean and Earth Science and Technology, University of Hawaii. The state data come from numerous volunteer observers such as sugar plantations, pineapple companies, individuals, and others. The state data are unrelated to the NOAA/NCDC (National Climatic Data Center) network. Metadata describing changes in the way the observations are taken from the handwritten records will be documented. All digitized data will be entered onto the spreadsheets and be provided to the funding agency.

Progress During FY 2004

We have compiled the state rain gages with more than 10 years of records for six major islands (Hawaii, Maui, Molokai, Lanai, Oahu, and Kauai). 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 opportunity for documenting long-term climate change and variability in the tropical Pacific. This set of state data, together with the federal network data, also provides an unprecedented spatial coverage of rain gages. This is important for understanding microclimate features across the island.

Fisheries Oceanography

Fisheries oceanography has become the largest component of JIMAR. The program has three components: 1) Collaborative research with the Pacific Islands Fisheries Science Center of the National Marine Fisheries Service (NMFS); 2) Collaborative research with the Pacific Environmental Group in Monterey, CA; and 3) 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 Fisheries Management Council.

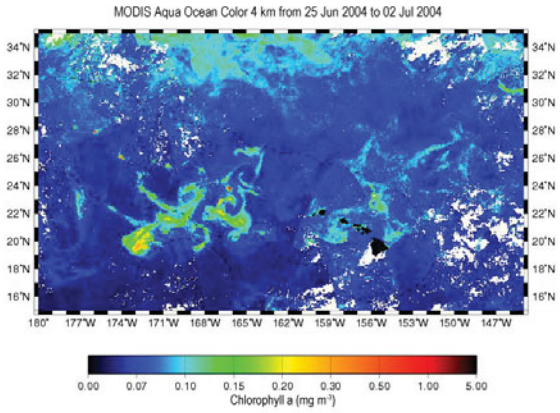
1) Collaborative Research with the Pacific Islands Fisheries Science Center

Applications of Satellite Ocean Remote Sensing to Living Marine Resources (Ocean Remote Sensing) [CoastWatch]

P.I.: Thomas A. Schroeder [Jeffrey J. Polovina]

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



Satellite remotely-sensed image of a phytoplankton bloom around the Hawaii Archipelago during the period June 25-July 2, 2004.

Purpose of the Project

This project develops and maintains a database of satellite oceanographic data including sea surface temperature, surface wind, sea surface height, and ocean color covering the Central and North Pacific. Staff members collaborate with fisheries researchers to use satellite remotely-sensed oceanographic data in fisheries and protected species research. The project develops and maintains a web site http://coastwatch.nmfs.hawaii.edu/ to display satellite remotely sensed data.

Progress During FY 2004

During FY04, the website was completely revised with an expanded focus from the Hawaii region to the entire North Pacific. A new ocean color product, Modis Aqua surface chlorophyll, has been added to the database. Collaborations with Pacific Islands Fisheries Science Center researchers using Ocean Watch data were undertaken. Presentation of results were made at various conferences and workshops, including the Honolulu ASLO meeting.

Western Pacific Fisheries Information Network (WPacFIN)

P.I.: Thomas A. Schroeder [David C. Hamm]

NOAA Goal(s)

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

Purpose of the Project

WPacFIN's ongoing goal is to improve 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, UH, NMFS, and the Western Pacific Regional Fisheries Management Council. It also gives technical support to participating WPacFIN fisheries agencies in American Samoa, Hawaii, Guam, and the Northern Mariana Islands. WPacFIN integrates local and federal data, shares it through WPacFIN data share agreements, and manages it locally on a central computer at PIFSC. It provides direct access to the data for qualified users and fulfills numerous data requests for researchers throughout the year. Routine annual report products from WPacFIN are used in "Fisheries of the United States," "Fishery Statistics of the Western Pacific," and in status reports for the Bottomfish and Pelagics Fishery Management Plans. In addition, the project maintains a WPacFIN Website at the PIFSC that provides public access to non-confidential fisheries data, charts, various reports, and general information on related fisheries and island agencies.

Participants for DIAS II Workshop; NOAA Fisheries/PIFSC, photo by WPacFIN

Progress During FY 2004

The WPacFIN JIMAR project met its objectives for FY2004. It 1) made significant progress in upgrading and maintaining all island data systems, 2) worked on new data systems to enhance data management, 3) implemented

Document Imaging Archival System (DIAS) at all island agency offices, 4) improved automated Fishery Management Plan (FMP) report generation, 5) further developed a report generator for the Coral Reef FMP, and 6) continued developing and revising the WPacFIN website. The JIMAR WPacFIN project has been very successful, and it produces many valuable data products for appropriate researchers and fisheries management clients. The website has also received numerous positive comments from a wide range of clients. The next paragraph provides more details for FY2004.

Participants for DIAS I Workshop; NOAA Fisheries/PIFSC, photo by WPacFIN

Refinements and upgrades to enhance data entry and quality control were designed and implemented for the new suite of forms in use by the State of Hawaii Division of Aquatic Resources (HDAR), and excellent progress was made on implementing a new aquarium fish monitoring and report system. Additional modifications and upgrades were made to American Samoa's Department of Marine and Wildlife Resources (DMWR) cross-system data integration applications. Data expansion algorithms were improved for the Guam Division of Aquatic and Wildlife Resources (DAWR) inshore creel survey, and discrepancies between the inshore and offshore system species code files were resolved. Programming of the remaining modules for the Guam DAWR commercial landings system was completed, and several other upgrades were implemented. A new Visual FoxPro (VFP) commercial landings system for CNMI's Division of Fish and Wildlife (DFW) was programmed and implemented, their offshore creel survey system was completed in FoxPro 2.6, and good progress was made on designing and programming their new VFP vessel classification system. Numerous improvements have been made to the DIAS, a highly customizable document imaging and archival system, following the first DIAS training workshop. Two additional workshops were held in December 2003 and January 2004 to train staff from all WPacFIN-participating agencies, and the software has since been implemented in each of the island offices. The design, programming, and implementation of automated annual report generators were completed for the Guam and CNMI Bottomfish and Pelagics Plan Teams, and they are still works-in-progress for Hawaii. Good progress was also made on improving production of the "Fishery Statistics of the Western Pacific" and "Fisheries of the United States" reports. Last, significant upgrades and major revisions (e.g., hundreds of new and improved WebPages) were made to the WPacFIN Website in the past year, and they continue to be made as resources permit. It is currently undergoing major reformatting changes to meet new NOAA and PIFSC standards. The current URL, <http://wpacfin.nmfs.hawaii.edu>, will be changing to <http://www.nmfs.hawaii.edu/wpacfin>.

Marine Resource Dynamics and Assessment Program (MARDAP)

The Marine Resource Dynamics and Assessment Program (MARDAP) provides a mechanism for collaborative research between NOAA scientists and the NMFS Pacific Islands Fisheries Science Center, JIMAR scientists, and other researchers at the University of Hawaii to address critical issues of marine resource assessment, conservation, and utilization in the Pacific. The program is primarily concerned with resources and fisheries of the Hawaiian Archipelago and surrounding central North Pacific waters in which Hawaii-based fishing fleets operate.

Cooperative Research

P.I.: Thomas A. Schroeder [Christofer H. Boggs]

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 was funded in July 2002 as part of the Marine Resource Dynamics and Assessment Program (MARDAP) to instigate and coordinate cooperative research between NOAA Fisheries Pacific Islands Fisheries Science Center (PIFSC) scientists, the fishing industry, fishery management, and academic researchers by encouraging collaboration, improving communication, and using the fishermen's expertise and fishing vessels to answer scientific questions of immediate importance to industry and managers. Specifically, the grant was established to fund work-

shops to develop integrated, comprehensive, prioritized proposals to be considered for funding as cooperative research projects for U.S. affiliated islands in the western Pacific. In 2004 the purview of the project was extended to include cooperative research to reduce marlin bycatch by tuna longline gear with funding provided by the Reducing Bycatch Program of NOAA Fisheries.

Progress During FY 2004

Workshops were organized and conducted by NMFS in American Samoa in July 2002 and in Guam (with CNMI participation) in October 2002 to solicit initial ideas for a more comprehensive workshop. A change in project leadership in 2003 and the new sponsor's prior commitments to other activities have resulted in a delay in organizing and conducting the comprehensive workshop. A workshop in Honolulu for the U.S. affiliated island researchers, which will utilize the $20 K budgeted for that purpose, is in the planning stage, in collaboration with the Western Pacific Regional Management Council. Hook timers were obtained for the research on fishing gear performance and dynamics from a cancelled NOAA Fisheries research project in 2004, and so funds originally earmarked for hook timers and for tagging ($25K) will be used for tags and to fund seagoing technicians to document experimental results.

An additional $209.9 K in funding was obtained for the project in FY 2004 from the Reducing Bycatch Program of NOAA Fisheries, to conduct a test and a commercially viable demonstration of modified fishing gear to reduce the incidental catch of marlin by tuna longline fishing.

Research Support

P.I.: Thomas A. Schroeder [Susan K. Kamei]

NOAA Goal(s)

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

Purpose of the Project

To provide support for fishery data monitoring and other support to research operations conducted at the Pacific Islands Fisheries Science Center located on the University of Hawaii, Manoa campus, and at the Kewalo Research Facility. The project provides current data and information on the Hawaii's Federal FMP fisheries in Hawaii.

Progress During FY 2004

Hired an administrative secretary to support the fishery data monitoring staff. The JIMAR Fisheries Specialist continues to provide support to fishery monitoring activities by providing timely, high quality data to JIMAR, NMFS, and other non-agency researchers. He participates in logbook collection from the Hawaii longline vessels, verifies the data, and monitors the Honolulu seafood market. There are approximately 1000-1200 trip logs that are processed annually. These paper trip log forms and their processing to final electronic form represent a large sink of time and resources. After a 5 year pilot program, the PIFSC proceeded on a path to formalize the use of an electronic longline logbook to provide a low effort, highly efficient, and accurate alternative to the paper logs. The JIMAR Fisheries Specialist is pivotal in the application of this alternate reporting instrument. Additional duties in 2004 include the collection, monitoring, and crosschecking of the new Shallow Set Certificates from longline permittees. The Certificates must accompany all logbook pages from vessels that fish for swordfish under the new regulations. Additional cross checking of the longline logbook and longline observer data have been instituted. Daily activities to reconcile trip data between the agencies have been established.

Economics of Fisheries Initiative

P.I.: Thomas A. Schroeder [Minling Pan]

NOAA Goal(s)

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

Purpose of the Project

The goal of this project is to provide an update of the value of commercial and recreational fisheries that are commensurate, and update and augment work initially developed under the Pelagic Fisheries Research Program. The project also investigates approaches to providing estimates of the economic value of protected species conservation.

These estimates would be used in the context of the Western Pacific Regional Fishery Management Council's Fisheries Management Plans (FMP) for issues concerning allocation between commercial, charter, sports, semi-commercial (termed "expense fishing" in Hawaii), and recreational catch of important target species, and in the cost-effectiveness and cost-benefits of protected species conservation. The specific objectives of this program in FY 2004 include:

1) Measurement of excess capacity and overcapacity and its application in fishery management;
2) Economic analysis of fishing tournaments in Hawaii;
3) Cost-earning study on the longline fishing vessels operated by Vietnamese-Americans in Hawaii;
4) Hawaii continuous commercial fishery economics data collection.

A blue marlin caught in the Ahi Fever fishing tournament; NOAA Fisheries/ PIFSC, photo by Minling Pan

Progress During FY 2004

Completed the analysis on the quantitative measurement of fishing capacity for four major fisheries under the management of the Western Pacific Regional Fishery Management Council - 1) Northwestern Hawaiian Islands (NWHI) lobster fishery, 2) NWHI bottomfish fishery, 3) Hawaii Pelagic longline fishery, and 4) American Samoa Pelagic longline fishery. In addition, a statistical analysis has been applied to investigate the causes of excess capacity for the NWHI lobster and bottomfish fisheries. Through statistical analysis, this study concluded that regulatory regimes and stock abundance has significant impacts on excess capacity of the two fisheries.

Completed a pilot study for the Economic Evaluation of Hawaii Fishing Tournaments which included 1) to investigate research approaches, 2) to design survey form, and 3) to field-test the questionnaires and survey methods. This year, about 600 survey forms were sent out to the anglers that participated in fishing tournament in Hawaii in 2004. A brief summary from last year's findings was sent out with this year's questionnaires. The project is in a stage of collecting responses and building a database for compiling and analyzing the data.

Big catches in a fishing tournament; NOAA Fisheries/ PIFSC, photo by Minling Pan

Established and implemented the continuous economic data system through the PIRO Observer Program in the NWHI bottomfish and Hawaii-based longline fisheries. Carried out the tasks including develop forms and instructions for its usage, to train observers who are responsible for economic data collection in the observed trip, and set up protocols of program implementation with PIRO observer staff.

Started a cost-earnings study on NWHI bottomfish vessels, finished person-to-person interviews with 4 vessels' owner/captains, about half of the NWHI bottomfish fleet. Also, extended the re-study effort of the Vietnamese-American operated vessels in the swordfish fishery; however, only a few interviews were conducted since most of the fishermen who remained in Hawaii switched to tuna fishing.

Lobster Research Program

P.I.: Thomas A. Schroeder [Gerard DiNardo]

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 are to assess (1) the status of lobster stocks in the Northwestern Hawaiian Islands (NWHI) and (2) the impact of fishing on these stocks. During a technical review of the NWHI lobster assessment procedures, it was recommended that collaborative research programs between industry, the National Marine Fisheries Service, Pacific Islands Fisheries Science Center (PIFSC), and the University of Hawaii (UH) be developed to (1) provide independent estimates of population size, (2) 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.

Progress During FY 2004

A 3-year NWHI lobster research plan was submitted and approved by the Western Pacific Regional Fishery Management Council (WPRFMC). Numerous presentations on the status of lobster research were also presented to the WPRFMC and at various international and national scientific conferences and symposia. Two commercial fishing vessels were contracted (chartered) from September 3 to October 5, 2003, to conduct lobster tagging experiments at Necker Island and Maro Reef. The charters were a success; approximately 10,000 spiny lobsters at Necker Island and 5,000 slipper lobsters at Maro Reef were tagged and released. The 2004 NWHI lobster resource survey was conducted from June 20 to July 15, and data from the survey are being edited and keypunched. Efforts are underway to contract two vessels to continue the tagging experiments in September 2004.

Significant progress on population model development and bycatch synthesis also occurred in FY 2004. A spatially-explicit population model for spiny lobster that incorporates all available fishery-dependent and fishery-independent data was developed using MULTIFAN-CL. 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. Bycatch associated with the NWHI lobster research survey was provisionally analyzed to determine the utility of using these data to assess fishing impacts. A more complete analysis will be conducted and the finding presented at the Third NWHI Scientific Symposium in November 2004.

Don't Duck Metadata

P.I.: Thomas A. Schroeder [Michael Parke]

NOAA Goal(s)

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

Purpose of the Project

Create metadata records for Pacific Islands Fisheries Science Center (PIFSC) geospatial data files.

Progress During FY 2004

Completed creating metadata and metadata index for all bathymetry datasets of Hawaii and NWHI, as well as other PIFSC geospatial data files.

Pelagic Fisheries Essential Fish Habitat Research

P.I.: Thomas A. Schroeder [Michael Parke]

NOAA Goal(s)

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

Purpose of the Project

Define essential fish habitats for Pelagic Management Unit Species for the Western Pacific Pelagic Fisheries Management Plan using spatially linked historical satellite data from the Coastwatch archives with historical longline logbook records for the longline fishery collected over the past 10 years. Utilize GIS to analyze and map the spatial patterns of pelagic fishery CPUE (Catch Per Unit of Effort) and environmental conditions using spatial overlays. Store the new data created by this analysis as part of the longline logbook data archive in the PIFSC Oracle database. This analysis can easily be extended to include endangered species interactions.

Progress During FY 2004

Hired temporary programmer/analyst to determine best methods of integrating the diverse data sets. Data integration and entry into Oracle database completed.

Sociocultural Profile of Pacific Islands Region Fishing Communities

P.I.: Thomas A. Schroeder [Stewart Allen]

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 is designed to develop a social and cultural database of fishing communities in Hawaii, Guam, Commonwealth of the Northern Marianas, and American Samoa. The goal is to provide a standard set of information for all Western Pacific fishing communities 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 communities with others nationwide also will allow us to document the unique social and cultural aspects of Western Pacific fishing activity, as well as reveal commonalities. Objectives are to:

Longline vessels docked at Honolulu's Pier 17; NOAA Fisheries/ PIFSC, photo by Amy Gough

1. Develop a database structure that is consistent with existing port profiles being used in other parts of the country, while adding elements relevant to the Western Pacific;
2. Collect and add to the database variables available from existing sources;
3. Develop a protocol for collecting port information not already available and begin collecting the highest priority information.

Progress During FY 2004

Databases were obtained from the Western Pacific Fishery Information Network, the State of Hawaii Division of Aquatic Resources (commercial marine license holders and trip reports), State of Hawaii Division of Boating and Ocean Recreation, and Hawaii Marine Recreational Fisheries Survey. A data book is being compiled with our analysis of data from the above as well as the Census; State of Hawaii Department of Business, Economic Development, and Tourism; Department of Health; Department of Education; and Department of Transportation, Harbors Division, and other divisions. Currently, we have collected data for 56 indicators, categorized by Fishing Participation and Infrastructure; Population; Education; Public Health Issues and Infrastructure; Crime; Government; Geography; Economy; Income and Poverty; Housing; Tourism; and Miscellaneous.

Indicators which are comparable across Hawaii and all of the flag territories are difficult to find. Certain standard information collected in a routine manner in all 50 states is not collected in the flag territories. Even the Census does not ask all of the same questions in the flag territories that it asks in the states, nor does it ask all of the flag territories exactly the same set of questions. As a result, the project is expected to meet objectives 1 and 2 (listed above) and part of objective 3 (identifying priority information needs) but may not begin collecting primary data to meet those needs within the project time frame (by October 1, 2004).

Protected Species Investigations

This work is conducted to support the NMFS Strategic Plan elements related to sustained fisheries and recovery of protected species.

Hawaiian Monk Seal/Cetacean Program

P.I.: Thomas A. Schroeder [George Antonelis]

NOAA Goal(s)

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

Purpose of the Project

A main purpose of the Hawaiian Monk Seal Program is to study the relationship between environmental/oceanographic parameters in the region of the Northwestern Hawaiian Islands and demographic trends of the endangered Hawaiian monk seal. Like monk seals, cetaceans are apex predators and represent an important component of the marine ecosystem. Cetacean stock identification, abundance, and population trends are needed throughout the Pacific Island Region to fully understand their role in this highly complex environment.

Weaned Hawaiian monk seal pup at French Frigate Shoals; NOAA Fisheries/PIFSC, photo by Brenda Becker

Progress During FY 2004

In FY2004, ongoing Hawaiian monk seal studies have involved documenting monk seal demography, as well as factors influencing population trends. Three of the six monk seal subpopulations were recently growing (Kure and Midway Atoll, Pearl and Hermes Reef), but growth appears to be slowing or stopped. The population at Laysan Island has grown some over the past decade, while numbers at Lisianski Island have slowly decreased. Finally, at French Frigate Shoals, the population is undergoing a prolonged decline. Continued population decline is predicted at French Frigate Shoals due to low juvenile survival and the subsequent lack of recruitment of reproductive females into the subpopulation. Recent investigations indicate that oceanographic changes may have a direct influence on juvenile monk seal survival and, thus, could have contributed to the recent lack of growth in monk seal numbers, especially at the western end of its range.

Swordfish Research

P.I.: Thomas A. Schroeder [Karen Sender]

NOAA Goal(s)

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

Purpose of the Project

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.

Progress During FY 2004

Continued support, enhancement, and development of the Hawaii Longline Observer System (LODS) has resulted in other Fisheries regions committing to migrating this information management system to their programs. Development of a national Fisheries Information System metadata catalog (InPort) was initiated and is an integral part of a collaborative effort along with NOAA Fisheries Science and Technology/FIS and the Southeast Fisheries Science Center to develop tools and services for FIS. InPort will provide national Fisheries Information System with a centralized repository for managing and accessing information about fisheries data and will initially support the inventory and documentation of fisheries dependant data, including Swordfish and other Highly Migratory Species (HMS). Presentations at NOAA Tech 2004, FIS and FSCS were made with emphasis on the NOAA Data Quality Act and information management. Continued support of the national FIS though Professional Specialty Group (PSG) participation and assistance to FIS project manager.

Marine Turtle Research Program

P.I.: Thomas A. Schroeder [George H. Balazs]

NOAA Goal(s)

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

Purpose of the Project

Local fishermen, Rico and Zack, helping the NMFS/JIMAR Marine Turtle Research Program with turtle tagging and health assessment fieldwork at Palaau, Molokai, July 2004. NOAA Fisheries/PIFSC, photo by Cody Hooven

The purpose of this project includes nine discrete elements that consist of: 1) research to reduce or mitigate high-seas and coastal fishery by-catch of sea turtles; 2) research of the general biology, life history, and ecology of sea turtles in coastal marine habitats and on nesting beaches; 3) monitoring population trends for stock assessments; 4) simulation modeling of long term datasets to better understand population dynamics; 5) health assessments and disease investigations with focus on sea turtle fibropapilloma tumor disease; 6) conduction of a 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 research results; and 9) experimentation with remote viewing digital imagery for sea turtle monitoring and research.

Progress During FY 2004

NMFS/JIMAR Marine Turtle Research Program outer island stranding team students with a rehabilitating turtle at the NMFS Kewalo Research Facility, June 2004. NOAA Fisheries/PIFSC, photo by Cody Hooven

Between July 2003 and June 2004, a total of fifteen scientists from Japan, Australia, Taiwan, and the islands of Hawaii and Maui spent between two and fourteen days in seven separate sea turtle workshops at the Pacific Islands Fisheries Science Center for collaboration research and training. A collaborative study was conducted for research training and information exchange on sea turtle comparisons between Hawaii and Australia. Algal samples were collected from the stomach contents of green turtles and forage reef habitats for algal biotoxin assays of toxic blue-green algae in fibropapilloma disease and poor body condition in green turtles on the islands of Oahu, Hawaii, Maui, Kauai, Molokai, and Lanai. Also, collaborative research was conducted in Japan and Taiwan involving pelagic sea turtle tracking to gain insight of the ecology of Pacific loggerheads relevant to longline bycatch and mitigation. A detailed dataset was assembled for analysis covering 24 years of sea turtle strandings and their causes in the Hawaiian Islands. The list of publications shown in this JIMAR report reflect the broad scope and intense magnitude of research accomplishments and progress.

Names of Students Graduating with M.S. or Ph.D. Degrees During FY 2004

Yvette Anderson, M.S., University of Florida.

Research Aimed to Reduce Sea Turtle-Longline Interactions

P.I.: Thomas A. Schroeder [Jana Yonat Swimmer]

NOAA Goal(s)

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

Purpose of the Project

A collaborative investigation is currently underway to characterize vision, hearing, and chemoreception in sea turtles so that a comprehensive assessment of potential sensory attractants and repellants 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 bait could potentially decrease the amount of sea turtle injury and mortality due to fisheries interactions. Research we've conducted relates specifically to the chemosensory capabilities and use of olfaction and vision in detecting food sources.

Loggerhead sea turtle (Caretta caretta) at the NOAA Sea Turtle Facility in Galveston, Texas. Experiments conducted by JIMAR and NOAA employees confirmed sea turtles' olfactory capabilities underwater. NOAA Fisheries/PIFSC, photo by Amanda Southwood

Progress During FY 2004

We conducted experiments at the NOAA-NMFS Sea Turtle Facility in Galveston, TX, during November 2003 to investigate the behavioral responses of loggerhead turtles to various chemical stimuli. We used a specially-designed "choice tank" to assess behavioral responses of loggerhead turtles to chemical cues. We used a food homogenate to test whether or not turtles showed signs of detection and attraction to food odors. Results show that turtles spent a significantly greater proportion of time in areas of tank where food odor was present, specifically in the central start chamber, during food trials compared with control trials (P = 0.014, N = 12). Turtles also displayed an increased frequency of detection and searching behavior during food trials compared with control trials (P = 0.010, N = 12). In the absence of visual cues, loggerhead turtles will respond behaviorally to the presence of food odors. Although sea turtles are thought to be primarily visual predators, our results show that chemosensory cues may also play an important role in aquatic food detection and location and may be a factor in attracting sea turtles to longline fishing bait. Potential means of masking bait odor are currently being investigated, and analysis of chemical compounds that may act as turtle repellants is ongoing.

Loggerhead sea turtle (Caretta caretta) in holding pens in S. Brazil. Turtles were brought to pens after their capture from longline fishing gear. Experiments were conducted on turtles' response to potentially repellent odors. NOAA Fisheries/PIFSC, photo by Yonat Swimmer

In collaboration with Projeto TAMAR and Mix Industries, we have also conducted tests of repellent bait modifications using captive and semi-wild loggerhead turtles in Brazil. Specifically, various odors were produced and turtles' feeding response was observed. Tests were conducted with turtles that had been in captivity many years, as well as turtles recently captured and brought into enclosed pens. Thus far, no repellent baits have been identified.

Protected Resources Environmental Compliance Initiative

P.I.: Thomas A. Schroeder [Margaret Akamine and Tamra Faris]

NOAA Goal(s)

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

Purpose of the Project

A. Develop and implement strategies to further recovery of federally protected species.

B. Conduct consultations under the Endangered Species Act and prepare biological opinions.

C. Revise and maintain the Marine Mammal Stranding Network to fulfill mandates under the Marine Mammal Protection Act.

D. Assists in analysis and strategies for management of federal fisheries so that federal mandates under the Endangered Species Act and the Marine Mammal Protection Act are met.

Progress During FY 2004

The objectives established for this period included: 1) Maintain 2 employees to liaison with community and local governments regarding the management and uses of coastal resources and their impact on protected marine species; 2) Develop and deliver a resources inventory, reporting scheme, and protocols for marine mammal emergency

response in the Main Hawaiian Islands; 3) Develop program for and conduct Protected Resources workshops for fisheries that interact with sea turtles, sea birds, and cetaceans; 4) Liaison with the Western Pacific Regional Fishery Management Council (WPRFMC); 5) Hire administrative support to create and log administrative records and answer document requests; 6) Purchase equipment for new and/or existing hires (computers, camera, video, light box, binoculars); 7) Conduct public meetings for protected species outreach program development; and 8) Work with communities to design and publish outreach materials.

During FY2004, the following were accomplished: 2 employees continued to work with the state and local authorities on fishing interactions with protected species and response to emergency events involving protected species. Several emergency response protocols, including a monk seal public birth protocol and a large whale disentanglement protocol with the Humpback Whale Sanctuary, were developed and veterinary services were retained on contract. One new staff person was hired to assist on all topics, including creating and logging administrative records and answering document requests. Staff worked with the WPRFMC to review fishery management plans and their impact on protected species. Equipment, including computers, projectors, and cameras, was purchased. Public meetings on monk seal research activities (e.g., tagging) were held on Molokai, Kauai, and the island of Hawaii. Staff worked with the Sanctuary to design boater outreach materials. We were unable to achieve the hiring of staff to develop protected species workshops for the Pacific region due to staff overcommitments and the resulting inability to develop a position description and work on the hiring process.

Sustainable Fisheries Initiative

P.I.: Thomas A. Schroeder [Alvin Katekaru]

NOAA Goal(s)

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

Purpose of the Project

The major focus of this project is to investigate and implement fisheries conservation and management programs consistent under the Magneson Stevens Fisheries Conservation Act (MSA) and other applicable laws such as to fulfill several objectives of the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), National Environmental Policy Act (NEPA), and various Executive Orders. The study also entails analysis of biological, environmental, social and economic issues such as protected species interaction mitigation including fishermen education and data collection/monitoring in domestic and international fisheries.

Progress During FY 2004

During FY 2004 we had significant progress in areas of protected species interaction mitigation, data collection and monitoring, and fulfilling objectives consistent with the MSA, ESA, NEPA, and various Executive Orders. We hired a sea turtle dehooking specialist to coordinate an education/outreach program to instruct fishermen in the proper ways to use dehooking tools to release hooked and entangled sea turtles. To date, over 35 fishermen and 45 observers have been trained in sea turtle dehooking techniques. Through the dehooking education program, we have created educational materials such as placards and videos.

We have hired two JIMAR employees responsible for reviewing observer data and monitoring protected species interactions with fishing gear and data related to fishery management actions. To date, they have debriefed over 50 observers returning from longline fishing trips and have reviewed and edited data from 114 longline trips.

We hired a permit specialist to assist us in improving our permit system and running it to its fullest potential. She has been responsible for creating and updating our permits database, implementing our shallow set certificate program, and ramping up the regional office to implement the High Seas permit.

We initiated three international sea turtle projects. The Papua New Guinea work plan development project, which took place in July 2004, looked at the best ways to educate longline and prawn trawl fishermen in bycatch mitigation. As a result, another project will be underway in October 2004 in Papua New Guinea that will involve a workshop with the longline fleet to explain sea turtle handling and release techniques, as well as other mitigation methods that have been tried in other fisheries. Currently underway is an observer training program in the Marshall Islands. This program will educate observers in sea turtle handling and mitigation techniques for the longline fishery.

2) Collaborative Research with Pacific Fisheries Environment Group

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

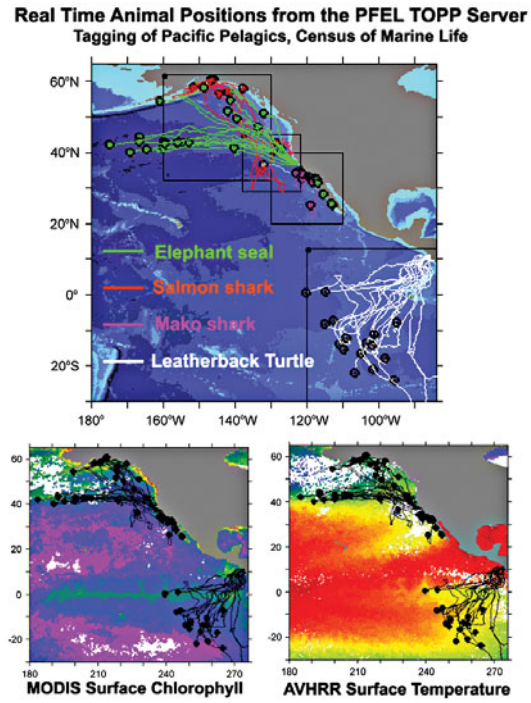
P.I.: Thomas A. Schroeder [R. Michael Laurs]

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 purposes of this project are 1) 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; 2) to conduct research required to improve modeling of marine fisheries and marine ecosystems important to marine fisheries, and 3) to conduct research related to the application of satellite remote sensing for marine fisheries and other marine ocean users requirements. These research efforts are being undertaken 1) to improve understanding of marine environmental variability and its impacts on living marine resources, 2) to develop improved living marine resource assessment models, and 3) to apply satellite remote sensing technology to improve the management of economically important marine resources.



Images from the Tagging of Pacific Pelagics web page showing near real time tracks of electronically tagged animals with respect to surface phytoplankton pigments and sea surface temperature maps generated by CoastWatch using data from the AVHRR sensors carried aboard the NOAA Polar-orbiting Operational Environmental Spacecraft and the MODIS sensor carried aboard NASA's Aqua spacecraft. Animals pictured include Elephant Seals, Leatherback Turtles, and a variety of sharks.

Progress During FY 2004

Virtually all planned research objectives for each of the three research projects under this Task were met this past year. Important activities conducted in the project to investigate variability in the North Pacific Ocean during this past year included: 1) continuing analysis of ocean climate variability, compared to atmospheric variability patterns; 2) developing and analyzing a variety of long time series and climate-relevant indices for identifying and characterizing abrupt and ecologically significant climate change events, using statistical methods developed in or adapted to this project; 3) continuing the analysis of global atmospheric teleconnection patterns of climate variability; 4) integrating data from multiple satellite-based sensors into the analysis of variability in the North Pacific; and 5) analyzing the signature of climate change on seasonal cycles in the atmosphere and ocean. From this research, long-term trends in the stratification of the upper ocean were identified that have considerable potential ecological importance. For example, in the California Current region, the coastal thermocline has strengthened and deepened over the past five decades, suggesting an explanation for the system's reduced biological productivity. This and other long-term climate variability is reflected in the timing and strength of the ocean's seasonality, which may have implications for marine species whose life histories are closely tuned to the seasonal cycle. From this research, a number of candidate indices representing environmental variability of importance to marine populations and ecosystem structure and productivity have been developed for possible operational use, e.g., 1) a close relationship between the position of the Transition Zone Chlorophyll Front (TZCF) in the North Pacific and ocean thermal structure based on satellite data, allowed the development of a proxy index of the TZCF back to 1960 and 2) other analyses helped characterize teleconnections between climate forcing of the North Pacific and Atlantic Oceans, enhancing our understanding of the global climate system.

Important activities conducted in the project to improve modeling of marine fisheries and marine ecosystems during this past year included 1) description of age and growth dynamics for protected sea turtle species, 2) identification and delineation of essential fish habitat for Chinook salmon of the coast of California by integrating archival tag data, in situ oceanographic observations, and remote sensing data, and 3) evaluation of the mechanisms by which ecosystem processes (e.g., predator-prey interactions and physically forced changes in food availability) influence the growth, maturation, and reproductive output of living marine resources. Notable accomplishments included: 1) validation of growth checks in sea turtle skeletons as annual increments; 2) cooperative work to capture, tag and release Chinook salmon with electronic archival tags resulted in 181 salmon being tagged and 20 of the tagged salmon being recaptured by fishermen; as well as the development of a website that allows researchers the capability to visualize all the data collected during the tagging project (http://www.pfeg.noaa.gov/products/las/salmon_tag_data.html); and 3) identification of changes in food availability as a major source of variation in the age at which coho salmon mature.

Major activities conducted in the project regarding satellite remote sensing technology included: 1) completed design and installation of automated computer systems for acquiring and processing geophysical satellite measurements and generating satellite ocean data and satellite-derived ocean data products; 2) expanded the suite of satellite data and satellite-derived ocean data products for distribution by NOAA West Coast CoastWatch (WCCW) site to users to include several SST data products from AVHRR (Advanced Very High Resolution Radiometer) and GOES (Geostationary Operational Environmental Satellites) sensors, ocean color data products from SeaWiFS and OceanSat satellites, ocean circulation data products from satellite altimeter sensors, and ocean wind products from satellite scatterometer sensors; and 3) redesigned the WCCW website for easy access by users to the improved and expanded suite of satellite data and satellite-derived data products that resulted in an approximate 10-fold increase in the amount of data downloaded from approximately 2.5 gigabytes per month to more than 25 gigabytes per month during the past year.

3) The Pelagic Fisheries Research Program (PFRP)

Pelagic Fisheries Research Program: Program Management

P.I.: John Sibert

NOAA Goal(s)

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

Purpose of the Project

To 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 2004

The PFRP completed another round of proposal solicitation. Thirty-two letters of intent, totaling over $3 million in requests were received. The PFRP Steering Committee invited 20 full proposals, and 18 proposals totaling $1.5 million in requests were received. The funds available for new projects was roughly $800,000, somewhat less than anticipated, and 12 proposals were funded with some deferred to FY2005.

The newly created Pacific Islands Fisheries Science Center (PIFSC) has taken on responsibility for administration of the PFRP from the Southwest Center. Some lack of understanding of the process and miscommunication between PIFSC and the PFRP caused some problems in establishing the PFRP budget.

The productivity of PFRP research projects remains high. A list of publications is attached to this report.

The PFRP remains active in international tuna research and management. The PFRP Program Manager was a member of the United States Delegation to the Fourth and Fifth Sessions of the Preparatory Conference for the Commission for the Conservation and Management of Highly Migratory Fish Stocks in Western and Central Pacific and to the Second meeting of the WCPFC Science Coordinating Group. Several PFRP scientists made presentations to the sixteenth meeting of the Standing committee on Tuna and Billfish in Mooloolaba, Australia, July 7 – 15, 2004. The PRFP Program Manager is Chair of the SCTB Methods Working Group and has been coordinating evaluation of stock assessment methods and specific stock assessment results. PFRP Researcher David Itano is Chair of the SCTB

Fishing Technology Working Group. Several PFRP scientists participated in the drafting the science plan new GLOBEC program, "Climate Impacts On Oceanic Top Predators" (CLIOTOP) expected to become active in 2004.

The 2003 PFRP PI meeting featured a special session on data rescue and sharing. The data rescue presentations emphasized the difficulties of interpreting old data in general and an invited presentation on pre-WWII Japanese fisheries suggested that it may be impossible to reconstruct the early history of Japanese fisheries. An invited presentation on data sharing provided useful guidance for PFRP initiatives to create data sharing mechanisms. A web site for sharing data from electronic tags is under development.

The PFRP actively promotes graduate education in fisheries. The PRFP Program Manager assisted in creating the proposal for a new Coastal and Marine Resources graduate degree program. The University has granted Authority to Plan and the newly established curriculum coordinator is funded by the PFRP. The first students for the CMR program are expected in Fall 2005.

The PFRP currently supports two graduate research assistants. Brittany Graham, a PhD candidate in the Oceanography Department, continues to be a productive member of the new pelagic food web project, "Trophic structure and tuna movement in the cold tongue-warm pool pelagic ecosystem of the equatorial Pacific." Richard Hall, a Masters candidate in the Geography Department, is expected to complete his project to explore the potential rolls for marine protected areas in the management of highly migratory species in 2004.

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

P.I.: John Sibert

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 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 2004

Most of the work of the project has been directed to continuing the development and application of the state-space extended Kalman filter model of animal tracks. Last year, a serious autocorrelated latitude bias was recognized in the light-based geolocation algorithms used by several manufacturers of archival tags. A statistical correction for this bias was added to the Kalman filter model. In collaboration with Dr. John Gunn of CSIRO and Dr. John Hampton of the Secretariat of the Pacific Community, this correction was applied to the analysis of fourteen tracks of bigeye tuna tagged with archival tags. The results indicate relatively restricted movements of most of these fish and a tendency to associate with topographic features such as the Queensland Plateau near Cairns, Australia.

In collaboration with Dr. Alan Bolten of the University of Florida, tracks of eighteen Atlantic loggerhead turtles tracked by Argos tags were analyzed using the Kalman filter model. Statistical tests indicated significant differences in the role of long-term directed movements in the behavior of these animals.

Anders Nielsen, a collaborator in the development of the Kalman filter track model, developed a preliminary method to objectively use temperature in estimating position from archival tag data.

Integrated Modeling for Hawaiian Albatross Populations

P.I.: Dan Goodman and Jean-Dominique Lebreton

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 analyze available information concerning Black-footed (*Phoebastria nigripes*) and Laysan (*Phoebastria immutabilis*) albatross (BFAL and LAAL for the sake of brevity in what follows) with the aim of assessing the status of their populations in relation with the potential impact of longline fisheries.

Progress During FY 2004

Administrative delays at CNRS (Centre National de la Recherche Scientifique) and difficulties of Bird banding Lab in Patuxent with data retrieval and their own analyses have caused significant delay in processing analysis. The main steps accomplished are:

1. Contacts and collaboration with USGS who conducted capture-recapture analysis of the Albatross data
2. Capture-recapture analyses specific to the present project

Problems arising from the irregularity of surveys conducted in different islands and variation in capture-recapture effort are being tested (collaboration with M. Maunder and S. Hoyle) by methods based on simulation in order to develop bias correction for the models to be used. We are also investigating cohorts effect in recapture probability.

The survival and recruitment models being developed have to account for this heterogeneity and to consider by-catch and/or fishing effort statistics as time-varying covariates in the capture-recapture models to investigate links between by-catch and Albatross survival.

An Albatross population model with two states (widowed and paired) has been written. In presence of an additional source of mortality, the drop in the growth rate is larger than in a model neglecting the cost of repairing after widowhood. The cost of repairing can be expressed as the equivalent change in mortality needed to obtain the same growth rate in a model not accounting for the cost. These results will be framed in papers next year.

Instrumented Buoys as Autonomous Observatories of Pelagic Ecosystems

P.I.: Kim Holland

NOAA Goal(s)

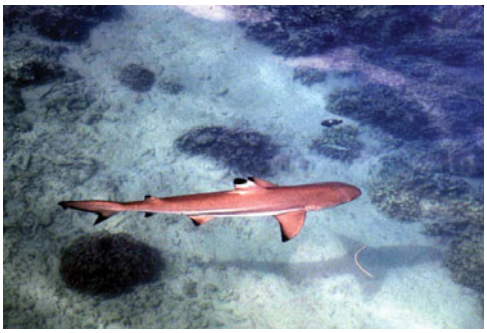
- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

Purpose of the Project

This project is designed to improve our understanding of the distribution of commercially important pelagic species. In particular, the project is investigating the temporal dynamics of the behavior of tunas when they are found in association with floating objects and to investigate the underlying biological reasons for these associations. Over half the world's tuna harvest is now taken from these types of structure-related associations and so understanding them has direct pertinence not only to estimating the size of the resource but to improved resource management based on ecosystem principals. We are developing pelagic observatories ("Smart FADs") that will assess the status of the pelagic communities that aggregate around them, and we are developing new "ecology" electronic tags that will be used in conjunction with the "Smart FAD" observatories.

Progress During FY 2004

Captive tuna facilities were established at HIMB (Coconut Island) and a custom-built transfer tank was installed on the collection vessel. To date, 100 yellowfin have been successfully transferred into captivity, and these animals have supported various aspects of the program's goals. Captive tuna have been used to obtain sonar target strengths with the fish at various angles relative to the sonar beam. This was achieved by simultaneous video recording of animals as they passed through the sonar beam. These results are currently being analyzed and will be used to assist in interpretation of data acquired from the acoustic observatories when they are deployed during the subsequent phases of this research program. Similar results were also obtained during field trials aboard the R/V Opah. During these experiments, a Simrad EK 60 sonar was used to



Blacktip Reef Shark carrying the first ever internally implanted "biosonic probe" that collected data such as the shark's heart rate and the sounds of other fishes swimming near the shark.

obtain target strengths of tuna aggregations associated with "S" FAD in Waianae. Experimental fishing confirmed that the target strength measurements were obtained from schools of yellowfin tuna.

Progress was made in developing three new types of "ecology" tags. The captive tuna were used to obtain passive acoustic recordings of the acoustic signature generated by the captive school of tuna. These data are currently being analyzed and will be used to assist in interpretation of acoustic data acquired around FADs in the open ocean. Second, we have recently tested a new "bioacoustic probe" developed by Dr. William Burgess (Greenfield Technologies, Santa Barbara, CA). The probe is designed to collect and record the ambient sound field around aquatic animals. We have successfully completed the first deployment of this probe in a reef blacktip shark, and the data are now being analyzed. This tag will be tested to determine its ability to detect the acoustic signature of a school of captive tuna. We have also recently successfully tested a stomach motility tag that will be used to study feeding behavior. The prototype "Smart FAD" is currently under construction under the auspices of Dr. Jules Jaffe (Scripps Institution of Oceanography). We anticipate initial deployment in the fall of 2004. Dr. Jaffe participated in field trips in Hawaii to familiarize himself with the conditions under which the prototype will be deployed, and one P.I. (KH) visited Dr. Jaffe's laboratory in La Jolla to assist in the preliminary design of the Smart FAD sonar.

One of the few setbacks in the overall progress of the program is that Dr. Jaffe's lab has experienced a reduction in the number of skilled technicians employed in his lab and hence progress on the production of the prototype is moving more slowly than anticipated.

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

P.I.: Yonat Swimmer, Mike Musyl, Lianne McNaughton, Richard Brill

NOAA Goal(s)

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

Purpose of the Project

The objectives of this project are two-fold: 1) to provide estimates of delayed mortality and morbidity in sea turtles following interactions with longline fishing gear, and 2) 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 2004

PSATs deployed in Costa Rica

We have worked in collaboration with local commercial fishermen and a non-government organization (PRETOMA) on the Pacific Coast of Costa Rica since November 2001 in order to attach PSATs on marine turtles incidentally-captured in longline fishing gear. We have successfully tagged 10 sea turtles (9 olive ridleys and 1 green *Chelonia mydas*) incidentally captured in fishing gear, and 5 free-swimming "controls" to which the behaviors of longline-caught turtles could be compared.

Leatherback turtle (Dermochely coriacea) caught in longline fishing gear off Brazilian coast. Photo credit: Gilberto Sales, TAMAR

Horizontal movements of turtles appear similar for longline-caught and control turtles both in terms of directionality as well as minimum distance traveled (4.6 nm vs. 7.7 nm per day for longline-caught and control turtles, respectively; $p>0.15$). PSATs were retained on average 56 and 60 days for control- and longline-caught turtles, respectively (range: 35 to 113 days). Turtles in our study that were incidentally-captured in longline gear (and for which we received some response from the satellite tag) all survived a minimum of 3.5 weeks, and most survived a minimum of six weeks post-release before the tag was shed. Our results indicate that olive ridley turtles apparently survive their encounter with longline fishing gear at least for the first two months post-release. Furthermore, based on statistical analysis of dive depth

data, there is no clear difference in the dive patterns between control vs. longline caught turtles.

Olive ridley turtle (Lepidochelys olivacea) on deck after it's capture on longline fishing gear in Costa Rica.

PSATs deployed in the North Pacific Ocean

Since September 2002, California-based longline fishery observers have placed 13 PSATs on loggerhead (*Caretta caretta*) turtles in the North Pacific. Of these, six PSATs have already transmitted recorded data and one failed to report. The remaining tags are presumably still on turtles and should report within the coming months. PSATs retention on N. Pacific loggerheads was significantly longer than on olive ridleys in Costa Rica. Average number of days at liberty for loggerheads was 88 (range: 30-192 days). However, we have been disappointed with the quantity data received both regarding geolocation and dive behavior.

Depth data is nearly non-existent for turtles tagged thus far. For one turtle, depth data was only recorded for the first three months after release. However, the last depth reading recorded three months later was 1,108 m, which would suggest a mortality, or a faulty mechanical release device (RD1,500) designed to jettison the PSAT at 1500 meters. Because no depth data were obtained prior to this one "mortality," we consider these data inconclusive. What little data obtained, however, indicate the turtle spent 75% of time within the top 10m during the day and remained slightly deeper at night, yet never exceeding 50m. Light-based geolocations as generated from PSATs were run through the Kalman filter model in order to determine turtles' most probable track for three turtles. We will continue to work with Anders Nielsen to refine these estimates based on incorporation of sea surface temperature data.

PSATs deployed in the South Atlantic Ocean

In January 2004, while participating in an experimental fishery aimed to reduce sea turtle bycatch in longline fisheries, we tagged a loggerhead turtle that had been previously caught in commercial longline gear and maintained in captivity in Southern Brazil for two months. This turtle was tracked for 76 days before the tag apparently shed. The turtle exhibited normal behavior for the duration of the track. A second loggerhead was tagged during a subsequent cruise in March 2004. We expect to receive data from the PSATs after 8 months after their release. We anticipate future opportunities to tag longline-caught turtles in the Brazil longline fishery in the coming year. This work is being conducted in collaboration with Projeto TAMAR/IBAMA.

Comparisons of Catch Rates for Target and Incidentally Taken Fishes in Widely Separated Areas of the Pacific Ocean

P.I.: William A. Walsh and Keith A. Bigelow

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 is intended to elucidate variation across very broad spatial scales in catch per unit effort (CPUE) for several widely distributed Pacific fishes. The specific intention of this research is to determine whether and, if so, to what extent, intra- and interspecific CPUE for several species are correlated throughout the Pacific Ocean. The work entails analyses and comparisons of fish catch and operational data gathered by the Hawaii Longline Observer Program of the National Marine Fisheries Service (NMFS), longline logbook records submitted by the Hawaii-based fleet, data from mainland U.S. fisheries and U.S. possessions, and western Pacific fisheries. This work continues and expands upon an earlier Pelagic Fisheries Research Program project (Distributions, Histories, and Recent Catch Trends with Six Fish Taxa Taken as Incidental Catch by the Hawaii-based Commercial Longline Fishery, by William A. Walsh and Samuel G. Pooley).

Progress During FY 2004

This project was funded in November 2002 and is in its second year. There have not been any specific problems per se. This project exhibited progress in 2004 as a result of completion of deliverables from the earlier project. For example, the blue marlin data corrections conducted under the preceding project have revealed errors and, thereby, yielded progress in the form of preliminary corrections applied to striped marlin and shortbill spearfish. These species of interest for this project are sometimes misidentified as blue marlin.

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

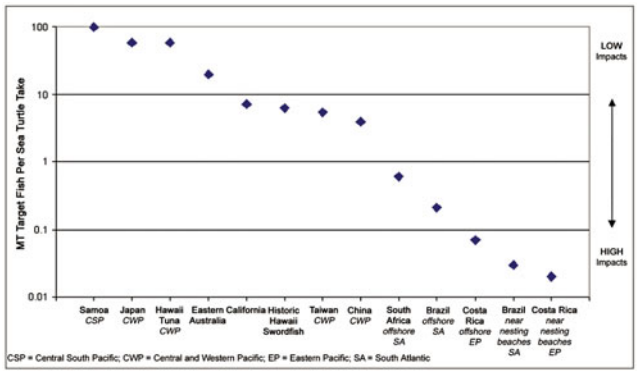
P.I.: Paul K. Bartram and John Kaneko (PacMar, Inc.)

NOAA Goal(s)

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

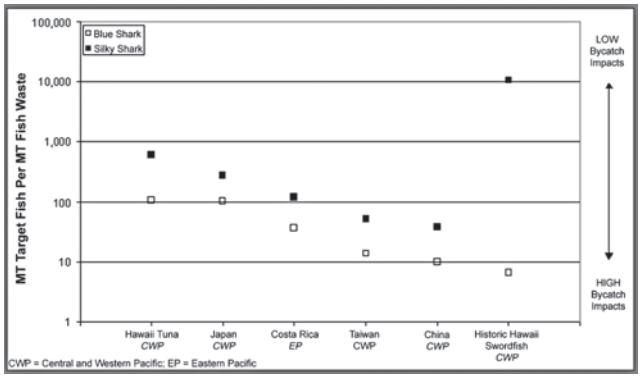
Purpose of the Project

The purpose of the project was to evaluate the incidental catch of sea turtles and bycatch of selected non-target fish species in Hawaii's pelagic longline fisheries and make comparisons with other pelagic longline fisheries using a methodology patterned after Hall (1996). The purpose was to put the true bycatch (fishery waste) associated with the Hawaii pelagic longline fisheries into perspective by using a standard of ecological impacts to make comparisons with other fisheries for the same target species available in the U.S. seafood market. In order to make meaningful comparisons on a ton-for-ton basis of marketed species, the ratio of BPUE (bycatch per unit effort) to CPUE (catch per unit of effort) must be calculated. Bycatch to catch ratios (B/C) and catch to bycatch ratios (C/B) provide a practical measure for comparison between fishery sources by relating bycatch impacts to a common volume of the targeted catch. By doing so, a method for quantifying the relative ecological trade-offs that result from management actions that promote shifts in fishing effort and shifts in the source of the market supply of the same species can be applied.



Catch to Bycatch Ratio (C/B): Mean harvest of target fish (mt) associated with one incidental sea turtle take in selected pelagic longline fisheries.

Progress During FY 2004



Catch to Bycatch Ratio (C/B): Mean harvest of target fish (mt) associated with one mt of shark bycatch in selected pelagic longline fisheries.

The pelagic longline fishing typologies were completed comparing and contrasting various pelagic longline fisheries with Hawaii's fisheries. C/B ratios (catch to bycatch) were calculated for these fisheries and plotted in descending order of adverse impacts on sea turtles (measured using incidental takes and not mortalities), for blue and silky sharks (measured using bycatch) and longnose lancetfish and shortbill spearfish (measured using bycatch). Comparisons with of C/B ratios have been prepared where possible in order to estimate the ecological trade-offs (in terms of sea turtle interactions) of substituting Hawaii swordfish with other sources. A final report has been prepared and submitted.

Causes of Rapid Declines in World Billfish Catch Rates

P.I.: Ransom A. Myers

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 aims to describe the pre-exploitation pelagic fish community and thereby identify key processes that influence responses to exploitation by longline fishing gear. To address those aims, the project consists of two components: (1) verification of longline catch and effort data as an index of abundance; and (2) quantification of community changes.

Progress During FY 2004

Catch rates, expressed as the number of fish caught per 1000 hooks, are often used as an abundance index for longline fisheries. However, the time that baits are available in the water should also affect what is eventually brought on board. We obtained data on catches, deployment and retrieval times, and soak time from six fisheries. We found that the effects of soak time varied between species, with catch rates of large predators increasing with soak time. Conversely, catch rates of small species were lower on hooks with long soak times, probably because they are lost or removed by scavengers. Consequently, historical variations in soak time and the timing of operations have introduced a systematic bias in estimates of mortality levels and abundance based on catch rates. We have also investigated the effects of soak time and timing on catch rates and tested the predictions of "habitat models." Habitat models predict the vertical distribution from information derived from tracking and physiological studies combined with data from oceanographic models of conditions in the fishing area. Our analyses show significant discrepancies between the observed distribution of bigeye tuna and that predicted by a habitat model. We concluded that habitat models might accurately predict the distribution of pelagic fish species, but this might not reflect their vulnerability to longline fishing gear.

To quantify changes in the pelagic fish community (component 2), we derived estimates of body-size and "abundance" (standardized catch rates) from a scientific survey when longlining began in the early 1950s and compared them to those reported by observers on commercial longliners in the same area of the tropical Pacific Ocean in the 1990s. The survey data extend the time-series of commercial fishing data that are routinely used in stock assessment and they also include non-target species, such as silky shark. We found major shifts in standardized catch rates and the size composition of species available to longline fishing gear. Large predators showed declines of a factor of ten, whereas small species increased or showed no change. The results suggest that either the initial changes in the pelagic fish community are greater than previously believed or that assessments have overlooked important features of the population dynamics or operation of longline gear.

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

P.I.: Valerie Allain, Brian N. Popp, Felipe Galvan-Magana, and Robert Olson

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

Recent 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. The project proposes to test this hypothesis by combining diet analysis, stable isotopic compositions, food-web modeling, and stable isotope markers to trace tuna movements and trophic-level variation in the equatorial Pacific. The hypothesis predicts that tunas that reside near equatorial upwelling fronts 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 study are:

1) to define the trophic structure of the pelagic ecosystems in the western, central and eastern parts of the tropical Pacific Ocean,
2) to establish an isotope-derived (upwelling-related) biogeography of the pelagic tropical Pacific ecosystems, and
3) to characterize large-scale tuna movements related to upwelling regions along the equator.

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 2004

2.1. Meetings

The second project PI meeting, funded by the project, took place in Noumea, New Caledonia, from 28 April to 2 May 2003. The four PIs, a collaborator Brian Fry and a Ph.D. student Brittany Graham attended this meeting. The first part of the meeting was dedicated to presentations made by the PIs and by colleagues from SPC; in the rest of the meeting a wide range of subjects about the project were discussed and a list of priorities was established.

The third project PI meeting of the project took place in Honolulu, Hawaii in December 2003 after the PFRP PI meeting. Three of the PIs attended (Felipe Galván-Magaña was absent) as well as Brian Fry and Brittany Graham; progress, future work and priorities were discussed.

2.2. Funding

An advance on the first year funding was credited to IATTC and CICIMAR in April 2003. The balance of the budget of year 1 ($67,225), that is the total amount for SPC and the remaining amounts for IATTC and CICIMAR, was transferred to the different partners in August 2003 ($36 were left on the account to keep it open for the year 2 budget and $5,150 were retained by JIMAR: 20.6% on the first $25,000). Bank transfer and exchange rates were higher than expected and not included in the budget.

CICIMAR and IATTC subcontracts with SPC for year 2 were signed in April 2004. An advance ($45,360) on funding for year 2 was asked in February 2004 but still not received by the 15th of April 2004.

2.3. Sampling on tuna fishing vessels

2.3.1. Western and central Pacific

In the western and central Pacific, observers of the National Observer Programs of the area collected samples. Sampling kits were distributed to Papua New Guinea (5 kits), Federated States of Micronesia (4), Solomon Islands (6), Marshall Islands (5), Tonga (1), Vanuatu (1), French Polynesia (6) and New Caledonia. One freezer was bought for storage of the samples in the Federated States of Micronesia and one in the Solomon Islands. Observers on longline and purse-seine vessels are collecting muscle and liver samples from 2 specimens of each species (tuna, shark, billfish and other bycatch species) per set. Predator sampling is widespread from Papua New Guinea to French Polynesia from west to east, and from the Federated States of Micronesia to New Caledonia from north to south. Since April 2003, 13 sampling trips have been completed: 1 longline trip in New Caledonia, 3 longline trips in French Polynesia, 1 purse seine trip in Papua New Guinea, and 8 longline trips in Solomon Islands.

Of the 1466 stomachs collected since July 2002 from 50 species of predatory fishes, 1169 have been examined in the laboratory. The most numerous predatory fish species are yellowfin tuna (176 specimens), bigeye tuna (111), skipjack tuna (257), albacore (79), blue marlin (21), sailfish (10), striped marlin (17), swordfish (18), blue shark (28), silky shark (13), short-finned mako shark (10), pelagic sting-ray (12), wahoo (62), lancetfish (65), dolphinfish (71), moonfish (36), escolar (19), rainbow runner (40), great barracuda (14), and frigate tuna (10). Data have been partially analyzed for three species: dolphinfish, lancetfish and wahoo.

Trophic level of the predators will be estimated using the stomach contents as well as stable isotope analysis of the muscle and liver samples. From the 1423 muscle and 1042 liver samples collected since July 2002, 700 and 696 samples, respectively, were freeze-dried for isotopic analysis since April 2003. A total of 172 samples of muscles and livers of different species of predators and prey have been isotopically analyzed.

In Hawaiian waters, under the primary objectives of the PFRP project # 757282, we have continued collecting a suite of samples from Hawaiian FADs and the Cross Seamount. Samples collected include prey items (i.e. stomachs contents) and tissue samples for isotope analysis from bigeye and yellowfin tuna ranging in forklength.

2.3.2. Eastern Pacific

In contrast to the western Pacific, sampling by observers onboard tuna vessels in the eastern Pacific Ocean (EPO) was not in force prior to initiation of this project. During the April 2003–March 2004 period, preparations for

sampling were completed and samples were collected on purse-seine vessels. Preparations included a field manual for the observers, observer training, and purchasing and transporting sampling equipment and supplies to Mexico and Ecuador.

Samples from 19 purse-seine trips were collected during the period covered by this report. These included 12 trips from Ecuadorian ports and 7 trips from Mexican ports. Samples and data are in hand for 39 sets associated with floating objects and 16 sets associated with dolphins during 14 of the 19 trips. The other 5 trips are still at sea. Set locations were widely distributed, from 25º N to 12º S and from 146 º W to 91 º W. The observers collected stomach, white muscle, and liver samples from the tunas and bycatch species. For several small non-target fishes that associate with floating objects, whole specimens were collected by the observers at sea. Sampling criteria are to collect 15 specimens per set for the tunas and all specimens available for the associated fishes, up to 15 specimens each per set.

The following numbers of species were collected during the period covered by this report: 555 yellowfin tuna, 412 skipjack tuna, 237 bigeye tuna, 5 black skipjack tuna, 16 frigate tuna, 231 wahoo, 203 dolphinfish (mahi mahi), 221 rainbow runner, 1 spinner dolphin, 131 silky sharks, 2 oceanic whitetip sharks, 1 thresher shark, 14 blue marlin, 1 shortbill spearfish, 392 triggerfishes and filefishes, 172 jacks, and 252 kyphosids and lobotids (small fishes that associate with floating objects).

2.4. Sampling on research vessels

2.4.1. Western and central Pacific

A sampling trip was undertaken onboard the Shoyo-Maru, a Japanese research boat, during a scientific cruise of the Fishery Agency of Japan in the western and central equatorial area. During this cruise, 29 samples of particulate organic matter, 12 zooplankton samples, and 45 forage specimens (fish, shrimps, squids), were collected, which will allow characterizing the low trophic levels.

2.4.2. Eastern Pacific

Samples were collected for this project by personnel of the U.S. National Marine Fisheries Service onboard two research ships in the eastern Pacific under the direction of the Stenella Abundance Research Project (STAR). STAR is a multi-year study designed to assess the status of dolphin stocks that have been taken as incidental catch by the tuna purse-seine fishery in the eastern Pacific Ocean. Both NOAA ships, David Starr Jordan and McArthur II, simultaneously surveyed a large portion of the eastern and central Pacific from July 29 to December 10, 2003 (for cruise track please see http://swfsc.nmfs.noaa.gov/prd/star/default.htm). Oceanographic data were also collected to characterize habitat and its variation over time.

Samples of zooplankton were collected every evening (weather permitting) by bongo net, and the contents of one side of the paired net were frozen for stable isotope analysis (n=156). Samples of particulate organic matter were collected and frozen almost daily by filtering seawater on to 25-mm glass fiber filters (n=199). Dipnetting for surface fauna was conducted every evening (weather permitting), and numerous specimens were shared with us for isotope analysis. These included flyingfishes (n not yet determined), mesopelagic myctophid fishes (n=400), cephalopods, and other miscellaneous fauna. Also, predator fishes were caught using trolling gear on an opportunistic basis when conditions permitted. The stomachs, liver, and muscle samples of some of these fishes were also collected.

The zooplankton samples collected on both STAR cruises were prepared for additional analyses by a graduate student from CICIMAR, La Paz, Mexico. M. Sc. Gladis López-Ibarra measured total plankton volumes, fractioned the samples into two equal parts, refroze them, and transported one part to La Paz for use in her Ph. D. research. She will analyze the trophic structure of major taxonomic components of the zooplankton assemblages, especially copepods, using stable isotope analysis. Ms. López's study, not an original component of the project, will be an additional output for this project.

2.5. Stomach content analysis

In the Western and Central Pacific diets of mahi-mahi, wahoo and lancetfish have been partially analyzed. Diets of the three species show different feeding strategies: dolphinfish is a surface piscivorous predator, wahoo also consumes small amounts of mesopelagic prey and if mainly piscivorous, it diversifies its diet eating small quantities of cephalopods and shrimps; lancetfish feeds at the surface and in deeper waters on fish and molluscs but also on small quantities of crustacea and invertebrates.

Stomach content analysis for samples collected in the eastern Pacific is underway at CICIMAR, La Paz, Mexico. To date, 1200 samples have been processed or partially processed. The data have not yet been analyzed.

2.6. Isotope analysis

Stable isotope analysis has advanced on 3 separate fronts: (1) analysis of predators and preys collected from the western and central Pacific, (2) a continuation of analysis of tuna caught around Oahu and the most intense effort has focused on (3) laboratory experiments on captive tuna.

First results of isotope analysis were received for the western and central Pacific: 172 samples of muscle and liver of different pelagic top predators and preys were analyzed for carbon and nitrogen isotopes. Several factors could explain the tendencies observed in the isotope values. Location seems an important factor: fish of the same species but from different locations have different values. Length may be another contributing factor. Nitrogen isotope values of predators also appear related to depth. More samples are needed to try to explain the values observed and are in the process of being analyzed.

Overall, the data collected from Hawaiian waters illustrates a distinct and rapid ontogenic shift in both yellowfin and bigeye tuna. The ontogenic shift, documented in both liver and white muscle tissues, will be modeled to provide estimates of tissue turnover in wild tuna. Currently we are writing up these results for publication. Aptly, these values will be compared to data collected in the diet experiments with captive tuna (Section 2.7).

2.7. Laboratory experiments

A tuna tank was constructed at the HIMB facilities, under the guidance of Dr. Kim Holland. Effort during the initial weeks after construction was focused on the transport and rearing of captive tuna. Shortly after the construction of the tank was completed, tuna were placed in the tank and serendipitously provided an ideal diet shift experiment to base future work on. More specifically, the diet fed to the tuna once in the tank (i.e. a mixture of squid and smelt) was isotopically distinct from the wild diet. A more rigorous diet shift experiment began in Feb. 2004 and is nearly complete. Overall, the tissue turnover rates of captive tuna are similar to those recorded f for mammals. These results are now being compiled for publication. Not only is the scientific community interested in the uses of stable isotopes to determine tissue turnover rates, but the results of these experiments will also enable us to better assess tuna migration and are at the foundation of future work.

2.8. Ecosystem modeling

2.8.1. Western and central Pacific

The preliminary model developed during the last quarter of 2002 has been greatly improved by adding several components to the model. Formulations of primary and secondary components (phytoplankton and zooplankton) have been improved, and the piscivorous fish group has been subdivided. The Ecopath model includes 20 functional groups: detritus, phytoplankton, zooplankton, crustacea, cephalopods, epi- and meso-pelagic fish, small top predators and adult top predators. Data inputs for each group are Biomass, Production, Consumption, Ecotrophic efficiency, catch and diet matrices. This new model has been compared to the previous one and tests on increasing effort and reaction to ENSO have been conducted. Further work is needed for the improvement of the model. The diet matrix will be improved using data collected in the area by the observer programmes in particular.

2.8.2. Eastern Pacific

A trophically-explicit, spatially-aggregated ecosystem model of the pelagic eastern tropical Pacific, developed previous to this project, using Ecopath with Ecosim, was published during the period covered by this report (Olson, R.J., and G.M. Watters. 2003. A model of the pelagic ecosystem in the eastern tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm., Bull. 22 (3): 133-218). The model will be reformulated based on new data describing trophic connections (diet data) and trophic structuring (stable isotope data) forthcoming from this project. Substantial improvements are expected because the existing model contains a paucity of information about the forage fishes and cephalopods at middle trophic levels, whereas this project will measure trophic positions of these taxa relative to those of the predators, based on stable isotope analysis.

Distributions, Histories, and Recent Catch Trends with Six Fish Taxa Taken as Incidental Catch by the Hawaii-based Commercial Longline Fishery

P.I.: William A. Walsh and Keith A. Bigelow

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 was designed to provide corrected catch rates for blue shark, blue marlin, mahimahi, wahoo, opah, and pomfrets taken by the Hawaii-based longline fishery. It has entailed development of statistical models from observer data with subsequent application to the logbook data from unobserved sets as comparison standards. This project is also contributing to improved linkage of data gathered by the NMFS Observer Program, the logbook program, and auction data from the United Fishing Agency, Ltd., Honolulu, Hawaii.

Progress During FY 2004

Recent activities under this project have focused on producing deliverables. A paper that presents corrected catch rates for blue marlin in the Hawaii-based longline fishery from March 1994 through June 2002 has been completed and is in review by *Fisheries Research* (a peer-reviewed journal).

No specific new problems have been encountered in FY 2004. The usual difficulty is that it is difficult to estimate the length of time required for the comparisons of model predictions, logbook originals, and auction data, simply because these tasks tend to be somewhat laborious and time-consuming. The blue marlin analysis, for example, required detailed checks on and correction of the catches from approximately 500 fishing trips since 1994.

The marlins project has contributed to improve linkage between observer, logbook, and auction data, in the sense that the work was conducted as an integrated analysis predicated upon use of the fishery observer data to develop a statistical model, application of its coefficients to logbook data as a comparison standard, and use of sales data to verify analytical results. The corrected blue marlin logbook catch data generated by these analyses have been incorporated into the ORACLE database at the Pacific Islands Fisheries Science Center.

Work conducted under this project and related work has been recognized and incorporated into agency-level planning at NOAA Fisheries. "Evaluating Bycatch: A National Approach to Standardized Bycatch Monitoring Programs," published by the NMFS in June 2003, cited Walsh (2000) ("Comparisons of fish catches reported by fishery observers and in logbooks of Hawaii-based longline vessels"; Southwest Fisheries Science Center Administrative Report H-00-07) and Walsh et al. (2002) ("Comparison of logbook reports of incidental blue shark catch rates by Hawaii-based longline vessels to fishery observer data by application of a generalized additive model"; *Fisheries Research* 58:79-94) in relation to the accuracy of both observer and logbook data and the characterization of forms of bias. This was noteworthy because although the report is lengthy (70 pages), its citations only include 34 listings, so the aforementioned work can legitimately be considered a substantive contribution to the current, relevant knowledge.

Recreational Fisheries Meta Data Project

P.I.: Paul Dalzell

NOAA Goal(s)

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

Purpose of the Project

The objective of this research is to document and compile into database formats all sources of recreational and sports fishing information over the past 50 years in Hawaii. This database provides fisheries researchers and managers with a convenient way to access all previous studies on recreational fisheries, plus where possible associated data. The database will contain previously undocumented sources of raw data from recreational competitions and tournaments. The ultimate objective of the project at its termination is to have the database incorporated and maintained within existing State or Federal fishery data management systems.

Progress During FY 2004

This project will terminate in 2004. Compilation of tournament data ceased in 2003. During 2004, work concentrated in establishing the project webpage (http://www.nmfs.hawaii.edu/fmep/recreation/index.html) and in completing two project reports to be published in the JIMAR series.

Development of a Hierarchical Model to Estimate Sea Turtle Rookery Contributions to Mixed Stocks in Foraging Habitats

P.I.: Benjamin Bolker

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 general methods for incorporating ecological covariates in genetic stock analysis models. Stock analysis attempts to estimate the proportion of the individuals in a mixed population that come from each of a number of possible source populations: for example, comparing data from breeding grounds and an open-ocean population that combines individuals from many breeding grounds to figure out the importance of particular breeding grounds to the overall population. In the past, stock analysis has been based only on individual morphological or genetic measurements, such as the mitochondrial DNA haplotypes of individuals found in rookeries and in mixed-stock foraging grounds. Other ecological information such as the size of the breeding population or the distance from the breeding population to the foraging ground is often available (and ignored). We are using stock analysis of Atlantic sea turtle populations (loggerhead and green turtles) to test and develop models that include ecological covariates such as rookery size and location, and drawing initial conclusions about the more powerful or different conclusions that come from incorporating this information. In particular, we are developing hierarchical Bayesian models, which are a flexible but rigorous way to add rookery size and geographic location to stock analysis methods that have traditionally used only genetic data to try to infer the contributions from each rookery. We are also developing important auxiliary statistical tools, such as model selection methods that can determine whether adding particular ecological covariates to an analysis actually increases the precision and accuracy of our estimates, or whether (if we mistakenly try to add irrelevant information to the model) it actually dilutes the power of the analysis; these tools are necessary before one can confidently start using hierarchical Bayesian methods as a general tool to add information to stock analyses. We are building software tools that implement these methods and that can be used by a broader audience of researchers. Finally, we hope to apply these general methods to some broader questions in stock analysis: for example, where should we define boundaries between populations for the purpose of stock analysis? How do we know when we have enough information to justify analysis at a very fine spatial scale or using very detailed genetic differences, and when should we be satisfied with analyses on a coarser scale?

Progress During FY 2004

A manuscript which we submitted last year, "Combining genetic and ecological data to estimate sea turtle origins," by Okuyama and Bolker, is now in press in *Ecological Applications*. It details the construction of hierarchical Bayesian models for sea turtle stock analysis, the testing of such models with a broad range of simulated data to see what conditions favor the use of such models over other (non-hierarchical) stock analysis tools, and the application of hierarchical Bayesian models to existing data on mitochondrial DNA haplotypes of green and loggerhead turtles in the Atlantic Ocean. This is one of the first uses of hierarchical Bayesian models in an ecological context, and is unique in its emphasis on using these models to incorporate additional ecological covariates in a flexible way.

We have continued to work on the model selection problem, which is the next one we had set for ourselves. We have continued to work on applying the Deviance Information Criterion (DIC) (a metric recently developed by researchers in Bayesian statistics, and described in our last progress report) to hierarchical models for sea turtle populations. We have found that hierarchical models are most valuable when small amounts of data are available from large numbers of sources (e.g., rookeries or feeding grounds); it is in this case that the hierarchical structure can provide the most additional information. Our manuscript on the subject is in progress.

We have pioneered methods for estimating contributions in a "many-to-many" stock analysis situation, where data are available from many sources (rookeries) and many destinations. In this case, we can incorporate rookery and

feeding-ground size directly (rather than hierarchically, although we are also exploring hierarchical versions of this model), and we can express contributions in either a "rookery-centric" way — percentages of individuals leaving each rookery for different foraging grounds — or in the more traditional "foraging ground-centric" way — percentages of individuals in each foraging ground coming from different rookeries. We have found that approaching this problem naively, by running a series of separate stock analyses for each foraging ground, gives misleading answers.

These methods have been briefly described and incorporated in a paper by Brian Bowen et al. (with 20 authors: BMB, TO, KAB, and ABB are all co-authors) on "Natal homing in juvenile loggerhead turtles (Caretta caretta)," in press, in *Molecular Ecology*, which shows for the first time (on the basis of stranding data) that juvenile sea turtles actually preferentially remain in the general vicinity of their natal rookeries, rather than forming a single completely mixed stock. We are also preparing a more general manuscript on many-to-many stock analysis using the large quantity of green turtle genetic data that KAB and ABB have amassed.

Satellite Remote Sensing

P.I.: Thomas A. Schroeder [Jeffrey Polovina]

NOAA Goal(s)

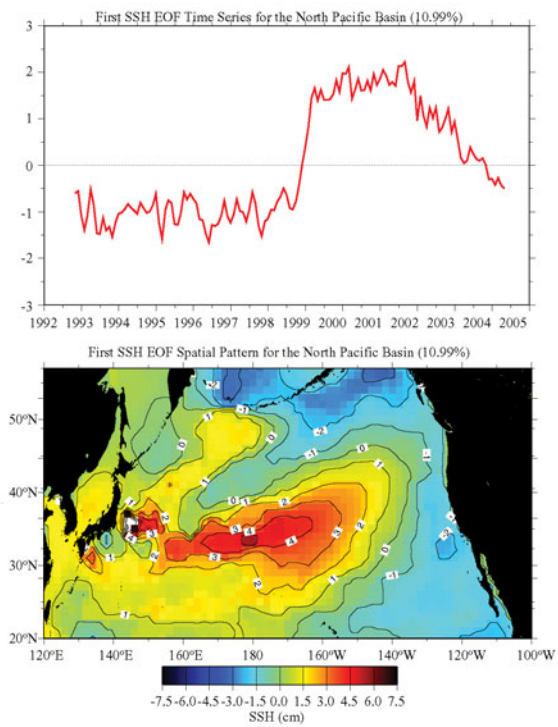
- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- To understand climate variability and change to enhance society's ability to plan and respond

Purpose of the Project

This project has two related aspects. To use satellite remotely-sensed oceanographic data to describe ocean dynamics, particularly features of importance to living marine resources and 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 2004

During FY04, pop-up archival transmitting (PAT) tags were deployed from commercial longliners on large pelagic fishes including bigeye tunas, albacore, and opah around the Hawaiian and American Samoa Archipelagos. Further, 15 PAT tags were deployed on whale sharks at Ningaloo Reef in the Indian Ocean.



First empirical orthogonal function of sea surface height in the central North Pacific

During FY 04, satellite remotely-sensed data were used to examine recent changes in the North Pacific. In particular, empirical orthogonal functions (EOFs) of sea surface height proved especially useful as indicators of ocean vertical structure and indicated recent changes in the Alaska Gyre, California Current, and Transition Zone. Results of this work were presented at the Ecosystem Indicators Conference in Paris and at a PICES (North Pacific Marine Science Organization) working group.

Sociological Baseline of Hawaii's Longline Fishery

P.I.: Stewart Allen

NOAA Goal(s)

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

Purpose of the Project

The Hawaii-based longline industry, which lands about 2/3 of Hawaii's commercial fish (measured in pounds; 2002 data), has been heavily regulated with little understanding of the socio-cultural impacts of those regulations and

management. The ethnically diverse makeup of longline industry participants in Hawaii and the transitory nature of the industry highlight the need for primary data on contemporary sociocultural characteristics. Project researchers are addressing this need by meeting two main project goals: compiling a comprehensive social profile of the longline fishing industry of Hawaii; and providing social profile information to decision-makers so they can better understand and manage the effects of regulatory impacts and implementation strategies.

Progress During FY 2004

Project researchers have interviewed 211 individuals involved with Hawaii's longline industry, reflecting slightly more than 60% of Hawaii-based longline vessels. These 211 participants included 70 vessel owners and captains, representing slightly more than 70% of Hawaii's longline owners and captains, along with 141 crew members, representing over 40% of Hawaii's longline crew. A qualitative/quantitative database with over 200 fields has been developed and 23 cases entered. The project is on schedule for completing data entry by October, 2004, and then beginning interviews with 30-60 members of the fish distribution network in Hawaii.

Direct Tests of the Efficacy of Bait and Gear Modifications for Reducing Interactions of Sea Turtles with Longline Fishing Gear in Costa Rica

P.I.: Yonat Swimmer, Randall Arauz, Christofer Boggs, Marti McCracken, Richard Brill

NOAA Goal(s)

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

Purpose of the Project

The objective of the proposed research was to determine the efficacy of a bait or gear modification that could significantly reduce the incidental capture of marine turtles in longline fishing gear. Specifically, we tested the effectiveness of blue-dyed bait in reducing sea turtle bycatch. An analysis of data made after 22 sets suggests that blue dye is not an effective sea turtle deterrent for longline fishing operations.

[The research was also designed to understand survivorship and behavior of sea turtles post-capture by placing pop-up satellite archival tags on turtles released from longline fishing gear. Results of this are more fully described in the JIMAR Annual Report entitled, "Survivorship, migrations, and diving patterns of sea turtles released from commercial longline fishing gear, determined with pop-up satellite archival transmitters."]

Progress During FY 2004

Two longline excursions were held simultaneously from December 1 to December 15, 2003, in order to test the efficacy of blue-dyed bait as a potential sea turtle deterrent. Sets were randomly alternated between blue-dyed and untreated bait. The two boats fished in the same general area for the duration of the trips to reduce confounding variables that could influence turtle bycatch rates. The boats made 22 sets, nine with blue dye and 13 with untreated bait within the EEZ of Costa Rica (Figure 1). Turtle catch rates were relatively high for both bait types, with a similar average CPUE of 8.4 vs. 8.1 turtles caught for every 1,000 hooks deployed for untreated and blue bait sets, which were statistically similar. During both trips, 108 olive ridley turtles (*Lepidochely olivacea*) and 7 green turtles (*Chelonia mydas agassizi*) were caught.

Because of low catch rates, due to warmer waters and possibly the blue dye, fishers required/demanded compensation, totaling approximately $2300, which was an unfortunate expense. However, because of our willingness to provide this compensation, the fleet is willing to continue to test another method in the near future. Based on these results, we believe we have sufficient data to determine that simply dying bait blue is not an effective means to reduce turtle bycatch in the fisheries.

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

P.I.: Pierre Kleiber and Hideki Nakano

NOAA Goal(s)

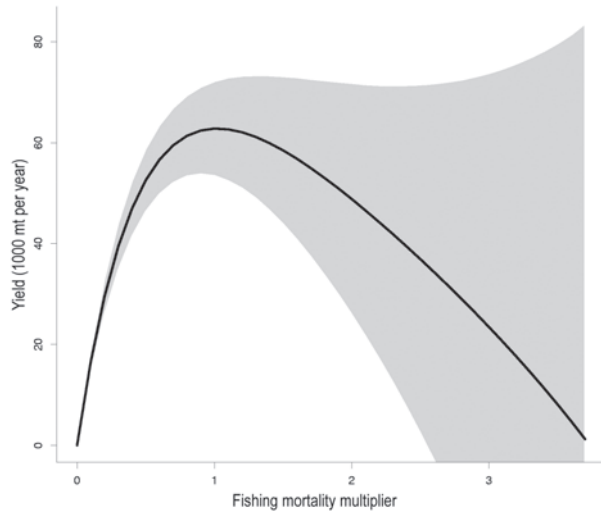
- To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management

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 2004

During FY 2004, this PFRP project developed a longline shoaling model for the Hawaii-based longline fishery. An estimate of longline shoaling was based on extensive analysis of 599 temperature-depth recorders (TDRs) deployed by fishery observers from 1996 to 1999 within the tuna (n=266 sets) and swordfish (n=333 sets) sectors. Longline shoaling for each set was estimated by the actual observed depth from the TDRs and the predicted depth based on gear configuration and catenary geometry. Shallow swordfish sets shoaled a mean of 51% (median=56%) with mean observed and predicted depths of 62 and 138 m, respectively. Deeper tuna sets shoaled a mean of 14% (median=30%) with mean observed and predicted depths of 248 and 342 m, respectively. About 17% of the sets had predicted depths that were shallower than actual depths. This results from a potentially biased longline sag rate and corresponding catenary angle estimated from gear configuration.



Equilibrium yield curve showing the fishing effort relative to current levels estimated to produce maximum sustainable yield of bigeye tuna in the central and western Pacific.

The project interacted with the NOAA Coastwatch central Pacific node and the PFRP Ocean Atlas project to develop indices to explain longline shoaling. Explanatory oceanographic and meteorological variables included: wind stress, surface ocean currents from various products (NCEP, AVISO, OSCARS), and horizontal current shear from the NCEP OGCM. GLM (Generalized Linear Model) and GAM (Generalized Additive Model) longline shoaling models were developed to explain longline shoaling as a function of predicted depth and oceanographic effects. Preliminary modeling efforts explained 40% of the shoaling for swordfish sets and 65% for tuna sets. The most important explanatory variable was predicted catenary depth. Oceanographic variables were of little explanatory value, possible due to a mismatch in spatio-temporal scale between longline sets and oceanographic data.

The computer specialist continued to work with a database system for assembling of catch, effort, and sample data into data files suitable for input to MULTIFAN-CL, the stock assessment program used in this project. He is in the process of developing a system to facilitate examination and editing of the complex parameter files incident to MULTIFAN-CL analyses.

Modeling Longline Fleet Effort Dynamics and Protected Species Interactions

P.I.: PingSun Leung, Naresh Pradhan, and Sam Pooley

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 refine and extend the existing fleet dynamic model, and the specific objectives and tasks are as follows:

1. Extend the longline trip level time-series dataset to 2002.
2. Reestimate the technical and economic interrelationships among different species landed and entry/stay/exit behavior using extended dataset.
3. Estimate the catch-effort relationships for each species and for each fleet.
4. Analyze the factors, rate, and degree of protected species interaction (e.g., turtles and seabirds) with longline fishing activities.

5. The information generated from 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 2004

The following summarizes the major activities during FY 2004:

1. The longline trip level time series dataset has been extended to 2002.
2. A surplus production model has been used to establish a catch-effort relationship of pelagic species in the longline fishery. The model was estimated by using a seemingly unrelated regression procedure to take account of the differential catchability of the inherent with different trip types in the longline fishery. The results are being evaluated at this time.
3. Analysis of sea turtle interaction with the longline fishery using Poisson and negative binomial regression models has been completed. It explored the factors, rate and degree of protected species interaction with longline fishery in the analytical framework of rare events using the count data models for the period 1994-2003. Fishing season, turtle population, and technologies used in catching fish significantly explained the turtle interactions with the longline fishery. Previous history of interactions had positive impact on turtles' interaction, but was not a significant one. Without a dramatic development of a technology to avert sea turtles in longline fishing, there is about 5% and 23% chance that one turtle will be encountered per trip in a tuna and swordfish targeted fishing trips, respectively. Few of the feasible factors that attributed significantly on turtle interactions can be regulated. A paper documenting the estimated models and results has been submitted to *Ecological Economics* for possible publication.
4. Modification and improvement of the existing fleet effort dynamic model in maximizing fishery welfare by incorporating protected species as well as new catch-effort relationships is currently underway.

Names of Students Graduating with M.S. or Ph.D. Degrees During FY 2004

Naresh C. Pradhan, Ph.D., Department of Economics, University of Hawaii.

Ecological Characterization of American Samoa's Alia Small-scale Longline Albacore Fishery

P.I.: John Kaneko and Paul K. Bartram (PacMar, Inc.)

NOAA Goal(s)

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

Data collectors meet the alia longliner late at night to collect information from the captain and to weigh and measure the catch.

Purpose of the Project

The purpose of the project is to characterize the American Samoa small-scale alia longline fishery for albacore in terms of catch composition, catch per unit effort of marketable species, incidental catch rates (live releases), and bycatch (dead and non-viable discards) of finfish and protected species. The small alia boats cannot accommodate fishery observers due to severe space limitations and safety considerations. As an alternative means to gain understanding of the ecological character of the fishery, the project has contracted one hundred fifty (150) alia longline fishing sets that require the captains to 1) retain the entire catch (with the exception of sharks and protected species), 2) maintain a tally of the catch indicating the status of the fish when hauled (alive or dead), 3) provide detailed information on the day's fishing to data collectors, 4) use a Global Positioning System (GPS) to record information on the location of the set, and 5) allow the catch to be identified to species, weighed, and measured after landing. The project will also test fishermen's knowledge of how to increase the percentage and viability of live albacore retrieved on longline gear. Experimental alia longline sets designed to test a strategy involving the modification of the typical alia fishing technique during the full moon sequence will be conducted.

Progress During FY 2004

Project planning and preparation was completed leading to the recruiting and training of American Samoa captains and crew in data reporting requirements for the contracted longline sets. Data collectors were trained in their responsibilities, fish identification, and the use of the GPS. To date, 141 alia longline sets have been completed and data recorded. Experimental longline sets have been conducted during the full moon phase with special evaluation of the albacore in the landings to determine the integrity of the swim bladder, which is easily ruptured during hauling. The final longline sets will be conducted in the month of August 2004, followed by data analysis and report preparation.

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

P.I.: Patrick Lehodey

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 support the nation's commerce with information for safe, efficient, and environmentally sound transportation

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 would help to model from ocean basin to individual scale. Both these types of models have been successfully applied to predicting tuna behaviors; IBMs at the very fine scale and ADRMs at the population level. The two classes of models 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. Mixed resolution models use a stretched grid system with greater resolution at one of multiple locations of the model domain. Therefore, the project proposes mathematical and programming developments in movement and spatial population dynamics models including a post-doctoral grant devoted to the development of an individual-based model (IBM). Though not included in the budget, a second post-doctoral study is closely associated to this project, as it will develop technics of local stretching for a grid generator that will be embedded into the coupled physical-biogeochemical model (ESSIC, Univ. Maryland) and the spatial ecosystem model (SEAPODYM, SPC) that will be used for predicting the oceanic environment of tuna and the large scale dynamics of their populations. The ESSIC model (co-P.I. R. Murtugudde, Univ. Maryland) will provide fields of predicted data (currents, temperature, primary production, and zooplankton biomass) with several areas of focus at higher resolution. These predicted data will serve as input in SEAPODYM that will provide predicted distributions of tuna forage (~micronekton) and tuna (skipjack, albacore, yellowfin, bigeye) biomass. The IBM will use the oceanic environment predicted by both ESSIC and SEAPODYM models. Behavior of tuna or other large pelagics predicted with the IBM will be compared to observed movements of individuals marked with electronic tags in selected study areas, and to spatial patterns generated by ADRMs.

Progress During FY 2004

Selection of candidates to the post-doctoral position was a lengthy process and recruitment to this position was delayed by administrative procedures and the request by SPC to have funds from the PFRP project in hand prior to being able to offer a contract to the post doc researcher. The first advance for this project was received in January 2004. Finally, the selected candidate (Dr. Gwenhael Allain) started his work at SPC on 15 May 2004.

During the months that preceded the first transfer of funds for this project, Dr. R Murtugudde provided to the P.I. the predicted fields from the coupled biogeochemical model for the period 1948-2002. Analyses of model primary productivity reproduced most of the observed interannual to decadal climate variabilities including the 1976 regime shift. In related synergistic activities, the salinity, iron, heat content, and freshwater fluxes in the North Pacific are being analyzed for their long-term behavior over 1948-2003. However, a drift in temperature predicted fields at high latitudes was detected and identified as a bias due to the lack of ice model. The problem was solved by introducing a "sponge layer" in the physical model and new simulations will be run.

Dr. Inna Senina, who has been recruited on the 'multi-grid' post-doctoral position, started her work in April 2004, at the University of Maryland under the supervision of R. Murtugudde. In June 2004, the P.I. visited his colleagues at the University of Maryland and provided the code used in SEAPODYM for the transport and that will be modified by I. Senina for using stretching techniques. It is expected to run the first tests after the PFRP P.I. meeting in December 2004.

Dr. P. Lehodey has upgraded the ecosystem model SEAPODYM that is now including 3 components of tuna forage: the epipelagic micronekton (in the layer 0-200m), the deep mesopelagic micronekton (in the layer 200-500m), and the migrant mesopelagic micronekton (moving from the layer 200-500m at day to the 0-200m layer at night).

Dr. Gwenhael Allain, who has been recruited on the "IBM" post-doctoral position, started his work on 15 May 2004. As a preliminary study, he is exploring the available archival tagging data in the Coral Sea for bigeye tuna (cf figure below), trying to identify typical patterns that could be related to changes in the oceanic conditions from observed and predicted physical (temperature, currents) and biological (biomass of different forage components: epipelagic, deep mesopelagic and migrant mesopelagic) variables (provided by R. Murtuggude and P. Lehodey).

As planned in the initial budget, $32,275 is being transferred to the University of Maryland. The rest of the advance ($35,250) will be used for covering travel, salary, and computer costs of the IBM post-doctoral researcher.

A General Bayesian Integrated Population Dynamics Model for Protected Species

P.I.: Mark Maunder

NOAA Goal(s)

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

Purpose of the Project

Managing wildlife-human interactions is increasingly important as human influence on natural habitats grows. Effective management requires defined objectives and reliable information about the likely consequences of management actions, or lack of such actions. These requirements are general across all taxonomic groups and management issues. Integrated Bayesian population modeling is a method for estimating population dynamics and decision analysis that is generally applicable, extremely flexible, uses data efficiently, and gives answers in a format that can be directly measured against management objectives. The objective of the project is to generate a general Bayesian integrated model for protected species modeling that can be applied to multiple species and used to provide management advice. The model will be used to estimate the effect of fisheries on the protected species populations. Methods will also be developed to estimate the effect of the management measures on both the protected species and the fisheries. We will apply the model to several protected species populations.

Progress During FY 2004

The present report reviews the activity under this contract for the 8 months from August 2003 up to the beginning of April 2004. The project start was delayed several months by the staff appointment process. The work to date has consisted of 5 main lines of activity:

- Development of an integrated model for dolphins
- Albatross modeling
- Development of general model
- Methodological development
- Other applications

These topics are briefly reviewed below.

a) Development of an integrated model for dolphins

- An integrated model was developed for the northeastern spotted dolphin population and used to estimate population parameters and conduct forward-project under alternative management scenarios.
- Contacts were made with cetacean researchers and modelers at the Southwest Fisheries Science Center, and a methods working group was established to provide a format for presentation and discussion of research related to this and other projects.

- A visit by SH to the Northwest Fisheries Science Center to meet with cetacean researchers and modelers is planned for June 2004.

b) Albatross modeling

- Albatross modeling was delayed due to difficulties at Patuxent Environmental Research Centre, USGS, in finalizing the mark-recapture database. These issues were resolved and the data became available in March.
- MM and SH met with Jean-Dominique Lebreton, Bill Kendal, and Paul Doherty at EURING 2003 to discuss the albatross mark-recapture database and analysis of the data
- MM and SH attended a weeklong course run by Jean-Dominique Lebreton and Roger Pradel on multi-state mark-recapture modeling using M-SURGE and goodness-of-fit testing using UCARE.
- MM and SH spent a week in Montpellier with Jean-Dominique Lebreton's group to work on analyzing mark-recapture data for the Tern Island population of black footed albatross and to develop a detailed work program for analysis of albatross data and development of integrated models. The Tern Island population of black footed albatross mark-recapture data has had irregular marking and resighting effort which causes serious goodness-of-fit problems. In collaboration with Jean-Dominique Lebreton and Sophie Veran, we developed an approach to solve the goodness-of-fit problems and generated first estimates of adult survival rate from Tern Island mark-recapture data
- SH developed an individual-based model of albatross population dynamics and capture probability for investigating lack of fit in mark-recapture models and in particular the problems with the Tern Island population of black footed albatross data.
- SH worked with Sophie Veran to investigate the effect of widowing in albatross.
- We made contacts for obtaining fishery effort data for integration into a model of albatross interactions with longline fisheries.

c) Development of a general model for protected species

A number of steps were taken towards developing and extending a general approach for modeling protected species. There has been some debate about how general a modeling approach can be, when applied across very varied taxonomic groups, and to what extent integration should be carried out.

- We have begun developing an approach based on multi-state matrix modeling, designed to be compatible with M-SURGE and its subprogram GEMACO (a concise language for specifying multi-state parameter index matrices).
- We have developed a framework to allow the application of MULTIFAN-CL to multiple-recapture mark-recapture data. We have an agreement with David Fournier to implement the necessary changes to MULTIFAN-CL and assist in its application to the Tern Island population of black footed albatross
- We have set up the Condor system (http://www.cs.wisc.edu/condor/) to allow for job scheduling across multiple PCs via distributed computing. This gives us access to additional PCs in the IATTC office, and greatly improves our ability to do simulation testing, management strategy evaluation, and possibly Bayesian integration. We have used this method for simulation testing of different methods to model temporal variation in survival for mark-recapture data.

d) Methodological development

- We have worked with Dave Fournier to test, using simulation analysis, the use of Laplace approximation, as implemented in AD Model Builder, for modeling a) recruitment in population dynamics models and b) survival in mark-recapture models as random effects.
- Evaluated, using simulation analysis, different methods to model time varying survival in mark recapture analyses (paper in preparation).
- MM and SH attended the EURING technical meeting in Radolfzell, Germany, October 2003 (http://www.phidot.org/euring2003/main_ie.html). This is the premier wildlife modeling meeting and provided instruction on the use of mark-recapture models and other wildlife modeling approaches. At the conference we also attended three short courses: (i) parameter counting and redundancy, (ii) goodness-of-fit testing, and (ii) Bayesian inference.

e) Other applications

- SH is attending a graduate course at the University of California San Diego's Scripps Institution of Oceanography on Global Issues in Sea Turtle Conservation and Potential Policy Solutions (http://cmbc.ucsd.edu/opportunities/sio.cfm). SH has also made contacts with turtle researchers in preparation for applying the Bayesian integrated modeling approach to a turtle population.

Evaluating Biochemical and Physiological Predictors of Long-Term Survival in Released Pacific Blue Marlin Tagged with Pop-up Satellite Archival Transmitters (PSATs)

P.I.: Michael Musyl, Christopher D. Moyes, and Richard W. Brill

NOAA Goal(s)

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

Purpose of the Project

Our objective is to use biochemical tools to predict the long-term survival of released Pacific blue marlin. We work in close collaboration with the PFRP projects by Musyl and Brill to place pop-up satellite archival tags (PSATs) on these fish and the Moyes, Brill, and Musyl project to develop biochemical correlates of delayed mortality in blue shark. We currently focus on assessing the extent of tissue damage arising from capture using comprehensive analyses of ions, metabolites, and proteins found in the plasma and muscle. We are also using the properties of blood cells themselves to assess the extent of systemic oxidative damage. Under stressful conditions, a series of genes are induced leading to synthesis of mRNA and protein corresponding to the heat shock proteins (hsp). We have used hsp70 induction in a number of fish models as an index of cellular damage.

Progress During FY 2004

The goals of the study were twofold. Firstly, we wanted to assess the survival rate among marlins released from sports fishing gear with PSATs. Secondly, we wanted to develop a suite of biochemical predictors of survival based upon blood/tissue samples of marlin prior to release. We also wanted to see if factors such as protracted fight times and type of fishing gear (e.g., pound test line, lure v. bait, "J" v. circle hooks) correlated with mortality. PSATs were placed on 38 marlins (36 blue, 1 black, and one striped).

One of the most burgeoning questions asked in fisheries research is whether released fish survive. For example, would prolonged fishing bouts correlate with increased stress and therefore a higher post-release mortality?

Twenty-nine PSATs have reported, and five of these reach their pre-programmed date. Only two tags failed to transmit data, and seven are assumed to be still attached to fish. For these 29 tags from which data were recovered, days at liberty ranged from 1 to 245 days (avg.=76 days) and we have in aggregate data from 2138 days (ca. 6 years) at liberty.

Vertical data from one blue marlin tag clearly indicate the fish sank and died approximately 4 months after release. The depth data indicate movements were relatively normal until 113 days after tagging. There were no indications in the vertical data prior to sinking that gave any suggestion of abnormal behavior. We are confident that this case represents a mortality because the PSAT worked as designed to detect a mortality (i.e. tag reached a "fail-safe" pressure release depth of around 1136m and jettisoned to the surface to start transmitting data). This fish was captured after a 25 minute fishing bout on live bait (hooked in the mouth). As correlated by a steady rise in SST estimated by the PSAT, the fish moved due south and covered ca. 855 nmi in 113 days. Since this fish apparently died about 4 months after the initial insult (catch-tag-release), we suggest that it would be very difficult to attribute this mortality to the initial insult, and that other factors (e.g., predation, disease, etc.) could have intervened.

In aggregate, the vertical data indicate movements during the day were constrained in the mixed layer with occasional forays beneath the thermocline (i.e., 97% of time spent from the surface to 150 m). Marlins show diel

vertical movement behavior typical of pelagic fishes and sharks (i.e., deeper in the daytime and shallower nighttime), but day/night transitions were not distinct (i.e., 85% of time at night spent from the surface to about 100 m). Day and night, marlins prefer temperatures of at least 27°C (i.e., 90% of time spent at these temperatures), and nighttime diving depth was not significantly correlated with lunar illumination. As measured by either deployment/pop-up locations or Kalman filtered-geolocations, blue marlin exhibited a mixture of 3 horizontal movement patterns: 1) neritic with movements close to the main Hawaiian Islands; 2) eastward movement from Kona (e.g., one tagged blue marlin moved almost due east for 59 days and covered 2, 096 nmi, or ca. 40 nmi/day); 3) southern-equatorial movements (e.g., one tagged marlin covered 1,434 nmi in 51 days). These movement patterns corroborate conventional tagging data.

Originally, our intention was to provide a direct correlation between biochemical measures and actual delayed mortality following release, as determined from the PSATs. Unfortunately, due to the unpredictable nature of large and dangerous marlin, we found it very difficult to take blood samples (or tissue) from restrained fish. Further, we did not want to compound handling stress by restraining fish any longer than necessary while attempting to take biochemical samples. Therefore, as we try and develop various devices to sample tissues from restrained marlin that are minimally invasive, tissue and blood samples have been taken from moribund and dead fishes to develop baseline biochemical information for our assays.

Pop-off Satellite Archival Tags to Chronicle the Survival and Movements of Blue Sharks Following Release from Longline Gear

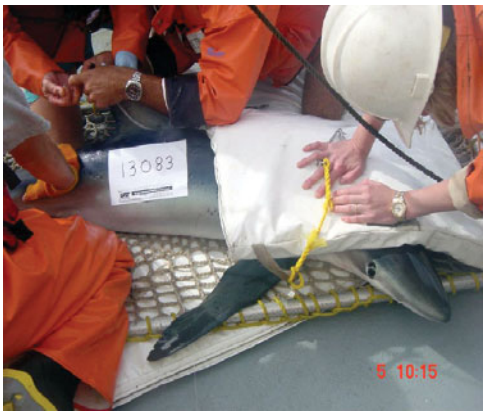
P.I.: Michael Musyl and Richard W. Brill

NOAA Goal(s)

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

Purpose of the Project

Our proposal to use "fishery independent" pop-up satellite archival tags (PSATs) to study the horizontal and vertical movements, and distribution of blue shark is intended to provide critical knowledge in three areas:



Scientists attach a pop-up satellite archival tag (PSAT) to a blue shark. The PSAT will collect and archive information that allows researchers to determine whether the shark survived and where it went (i.e., horizontal and vertical movement patterns).

1) Daily horizontal and vertical movement patterns, depth distribution, and effects of oceanographic conditions on the vulnerability of blue sharks to longline fishing gear. The time blue shark spend at certain depth or temperature strata, can be used to better refine CPUE indicies in the Pacific. 2) The survival rates of blue sharks captured and released from commercial longline fishing gear. The morbidity of released fish will also be determined by examination of diel horizontal and vertical movement patterns (Carey and Scharold 1990) and correlated to biochemical assays performed on the tagged fishes (linked to the Moyes et al. PFRP project to examine stressor proteins and other biochemical correlates of delayed post-hooking mortality). These results will have immediate impact in terms of management strategies for this species. 3) Stock identification, dispersal, and possible fishery interactions. These, as well as critical pupping areas and possible genetic structuring in blue shark, will be elucidated by the examination of dispersal patterns (Hays, 1992; Avise, 1994; Lutcavage et al., 1999). In addition, knowledge of the movement patterns of cohorts tagged near the Hawaiian Islands will help elucidate the overall stock composition in the Pacific, and the relationship of fish caught here to those caught elsewhere. That is, are blue shark caught near Hawaii part of a larger ocean-wide population or could they be considered a separate group for management and conservation purposes?

Progress During FY 2004

To date, we have deployed 128 PSATs on 28 swordfish, 38 marlin (36 blue, 1 black, 1 striped - see Musyl, Moyes, Brill and West PFRP project), 7 tunas (4 bigeye, 3 yellowfin), and 55 sharks (7 bigeye thresher, 32 blue, 8 oceanic white-tip, 4 short fin mako, 4 silky sharks) in the central North Pacific Ocean. The objectives of the project are to determine horizontal and vertical movement patterns, and rates of survival following release from longline and

recreational trolling gear. In a companion study, led by colleague Chris Moyes at Queens University, we are trying to quantify rates of morbidity and mortality in pelagic sharks and billfishes using a suite of biochemical assays to determine levels of stress from blood and tissue samples (see related PFRP projects by Moyes et al. and Musyl et al.). We thus hope to develop cost-effective biochemical techniques capable of predicting the chances of long-term survival in released fish.

PSATs were either directly harpooned with nylon or metal tag heads (swordfish, tunas, marlins, and bigeye thresher sharks), or placed through the dorsal fin (other sharks) with a stainless steel cable harness. PSATs were programmed to release 1,2 4,8, and 12 months following deployment. Early detachment is a continual problem. However, our new tether system with stainless steel ball-bearing swivels and arrowhead design augmented with spear gun flopper blades (to promote greater resistance) appears to be working well and numerous colleagues have requested the design and materials. Tag head improvement is an ongoing project and recently project personnel have collaborated with Eric Prince (NOAA Fisheries, Southeast Fisheries Science Center) in this endeavor.

Shark scientists also take blood samples of released sharks in order to develop biochemical predictors of morbidity and mortality. Research shows that sharks can lose perhaps 75% of their blood volume (measured as hematorcrit) and still survive.

Describing Habitat of Bigeye and Albacore Tunas

P.I.: Jeffrey Polovina and Mike Seki

NOAA Goal(s)

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

Purpose of the Project

To describe the vertical habitat and horizontal movements of bigeye and albacore tunas in the central Pacific.

Progress During FY 2004

In August 2003, 7 popup archival transmitting (PAT) tags were deployed on bigeye tunas from a commercial longliner in the northern subtropical gyre, north of Hawaii, and in March 2004 6 albacore and 3 bigeye PAT tags were deployed in the south Pacific around American Samoa also from a commercial longliner. The work in American Samoa was done in conjunction with an oceanographic cruise of the longline fishing ground by the NOAA vessel, Oscar Sette.

Regulatory Impact Analysis Framework for Hawaii Pelagic Fishery Management: A Multilevel and Multi-objective Programming Model

P.I.: Keiichi Nemoto and Samuel Pooley

NOAA Goal(s)

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

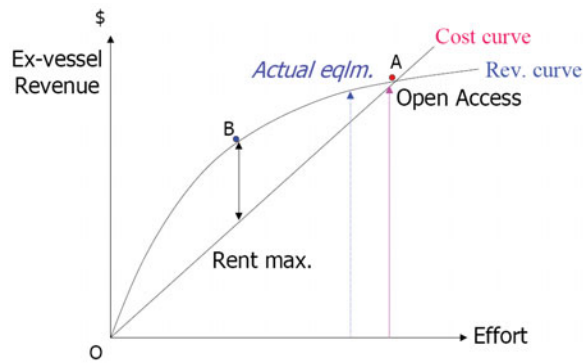
Purpose of the Project

The objective of this project is to enhance a previously-developed multilevel, multi-objective programming model (MMPM) for the Hawaii fisheries, which will allow fishery managers to simulate existing and potential regulatory policies with more flexible time-area specification.

Progress During FY 2004

The updated nonlinear programming model, implemented by General Algebraic Modeling System (GAMS), was validated by comparing the simulation results with the actual data from 1993 and 1998. By using the 1998 results as a baseline (i.e., assuming that prices and abundance levels of the major species for the Hawaii longline fishery (HILLF) in 1998 are given), the impacts of two recent policies to conserve sea turtles were assessed. In details, the North Pacific Ocean was divided into five areas: the main Hawaiian Island area and four adjacent areas: North-East, North-

Center, North-West, and South. Under the first turtle conservation policy during December 1999 – March 2001, North-Center area (28° – 44° N and 145° – 168° W) was closed. Under the second policy during April 2001 – March 2004 (where all shallow sets were prohibited year around), South area (south of 15° N above the equator) was closed during April-May. Likewise, each year is divided into five periods to simulate the above seasonal closure and capture seasonal variation of fish price and CPUE. Using a couple of data processors developed in the previous fiscal year, all necessary parameters were generated under the above time and area definition.



Actual equilibrium point for the Hawaii longline fishery, compared to two distinct scenarios – open access (A) and rent maximization by a sole owner (B)

The time series data of auction prices of nine major pelagic species were analyzed to estimate fishermen's expected price for each species. Results from this price analysis indicate that fishermen generally expect (i) higher price ($/lb) for bigger fish except for swordfish and blue marlin; (ii) there was statistical evidence that more landing of each species by the HILLF would decrease its price, although a measure, "price flexibility," was inelastic (7 – 39%), in particular, for swordfish and yellowfin and bigeye tunas (less than 10%), which are regularly shipped to outside of Hawaii markets. Because fishermen's decision regarding whether or not to go fishing and where to fish is very sensitive to profitability (i.e., fish price, CPUE, and costs), the above results suggest that the model for HILLF should incorporate this supply effect. Meanwhile, the model prediction suffered from certain errors: i.e., more longline sets were actually conducted under the second turtle conservation policy than predicted. These errors were primarily caused by a significant change in the cost-earnings situation of the HILLF, in particular, a reduction in operating costs by employing more foreign workers as crew (see another PFRP project "A Sociological Baseline of Hawaii's Longline Fishery"). Thus, it is urgent to update the cost parameters and functions of the model for the HILLF.

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 Islands 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 the U.S.-Affiliated Pacific Islands.

PIRO Coral Reef Management Initiative

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

NOAA Goal(s)

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

Purpose of the Project

A project to enhance the management of coral reef habitat throughout the U.S. Pacific Islands is proposed. 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), and Habitat Conservation Program (HCP). The CRMI will relate 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 will assist resource managers in attaining this goal. It will also enhance interagency cooperation and information exchange as well as develop new technologies for coastal resource management. A major 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 HCP. 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 reefs.

Progress During FY 2004

Continued field assessments at Guam, Saipan, Kwajalein, Palau, and in the Hawaiian Islands related to inventorying resources and/or assessing post-development recovery and mitigation success. Continued participation in the interagency coral reef mitigation working group involving Federal and State government representatives for the purpose of streamlining and standardizing mitigation review. Also participated in workshops on coral reefs, habitat restoration, climate change and coral reef bleaching, coral reefs and land-based pollution, EPA conference, artificial reefs, NEPA, the Clean Water Act, and sea turtles. In addition, a coral reef GIS database has been established from the ground up using local knowledge of government resources and those within the National Oceanic and Atmospheric Administration (NOAA). Images and related information have been catalogued, and spatial indexes of available aerial imagery, remotely-sensed data, habitat maps, and NMFS projects have been created. This database will be extremely useful in evaluating impacts to coral reefs due to fishing, development projects, or other sources.

Established a field office in American Samoa to address coral reef conservation issues. Tasks include assisting with the Ocean Resource Management Plan (ORMP) developed to "provide a structure for managing American Samoa's marine resources in a manner that balances ecological, economic, and cultural needs." Involved in the Watershed Advisory Group on prioritizing issues, evaluating strategies, and developing actions that assist with the Watershed Protection Plan of the ORMP. Participated in a Community-based Fisheries Management Workshop held in December 2003 and facilitated a discussion on ways to improve the program in the Territory. The American Samoa Coral Reef Advisory Group (CRAG) developed a Local Action Strategy (LAS) to address four major threats to American Samoa's coral reef. These threats are Land-based sources of pollution, Over-fishing, Human Population, and Climate Change. Assisted in the development and the implementation of the Over-fishing LAS as a member of the CRAG. Also involved in the Marine Protected Area (MPA) Working Group, which is a sounding board that makes recommendations to CRAG on MPAs and related issues. Assisted MPA working group members in updating information on American Samoa's village MPAs in the Marine Managed Areas (MMA) website.

Sustaining Healthy Coastal Ecosystems

P.I.: Thomas A. Schroeder [Russell E. Brainard]

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, restore, and protect coral reef ecosystems of the U.S. Pacific Islands. The goals of this program are to 1) improve understanding of coral reef ecosystems through assessment, long-term monitoring, and applied research, 2) evaluate and reduce adverse impacts to coral reef ecosystems with particular emphasis on those related to fishing activities, 3) enhance coral reef fisheries management and conservation by providing scientific support to assist the development and implementation of a Coral Reef Ecosystem Fishery Management Plan, and 4) provide the scientific basis to expand, strengthen, and establish marine protected areas (MPAs) to conserve coral reef resources of the U.S. Pacific Islands.

Giant clams (Tridacna maxima) at Kingman Reef, U.S. Line Islands. Photo by L.S. Godwin, Bishop Museum

Progress During FY 2004

During 2003-2004, the Sustaining Healthy Coastal Ecosystems program conducted multi-disciplinary research cruises to conduct baseline assessments of the fish, corals, other invertebrates, and algae in the context of their benthic and oceano-

graphic habitats of the coral reef ecosystems of the Northwestern Hawaiian Islands (NWHI), the Territory of American Samoa, and the remote U.S. Line and Phoenix Islands, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). These research cruises also conducted benthic habitat mapping activities consisting of multi-beam acoustic surveys and towed diver and towed camera optical validation surveys.

Ecological Assessment - Fish

Interesting results continue to emerge from ongoing fish surveys and data analysis in the U.S. Pacific Islands. In February 2004, eleven years after a major ship grounding occurred at Rose Atoll, American Samoa, both numerical and biomass densities of pooled herbivorous fishes (surgeonfish, parrotfish, and angelfish families) were several-fold greater at the wreck site than elsewhere around the atoll. The greater abundance of herbivores at the impact site, where corroding steel debris was still present, was associated with significantly greater substrate cover of turf algae/cyanobacteria. Continuing long-term periodic monitoring will contribute to our understanding of recovery rates by coral reef fish assemblages from such major anthropogenic disturbances, and to the scientific basis for management. Also in American Samoa, some interesting differences were found for large fishes (such as groupers) between the remote, mostly uninhabited islands and Tutuila Island, the main population base. At the Equatorial Islands (Howland, Baker, Jarvis), temperature profiles revealed nutrient-rich upwelling along the west side of these islands, which were associated with much higher densities of planktivorous fishes, in contrast to non-upwelling Equatorial Islands (Palmyra and Kingman). In the Northwestern Hawaiian Islands, the first monitoring cruise of July-August 2003 continued to document high abundance of top-level predators (mainly jacks and sharks), following completion of baseline assessments in 2000-03. In August-September 2003 the first baseline assessment cruise was conducted for the reefs of Guam and the Northern Mariana Islands. On this cruise, many range extensions were recorded for fishes; also, as in American Samoa, sharks, groupers, and other large fishes were noticeably less abundant near Guam and the inhabited areas of CNMI like Saipan and Rota.

Ecological Assessment – Corals

In June, 2004, nine JIMAR scientists delivered oral or poster presentations representing work accomplished through Pacific Islands Fisheries Science Center's Coral Reef Ecosystem Division (CRED) at the 10th International Coral Reef Symposium in Okinawa, Japan. Attended by more than 1400 coral reef scientists, managers, and policy makers from 25 nations, the Symposium is held every four years to present and discuss the science and management of coral reef ecosystems. Two CRED presentations focused on the mass coral bleaching event that affected the NWHI in late summer 2002. Follow-up surveys throughout the NWHI roughly one year following the mass bleaching event (July/August 2003) suggested that some coral genera (*Pocillopora* and *Porites*) were tending towards recovery, while others (*Montipora*) were tending towards degradation. During 2003 surveys, low levels of coral bleaching, not unexpected during normal high-temperature summer months, were observed at numerous sites. An additional CRED presentation at the Okinawa symposium focused on the first two years of data generated from larval recruitment plates that are annually deployed and retrieved at six locations throughout the NWHI.

Benthic surveys conducted in the NWHI in 2003 were designed to initiate "monitoring" by selecting specific sites from the suite of sites that have been assessed by CRED and partners since 2000, with the aim of resurveying these sites during subsequent expeditions. Similarly, benthic surveys in American Samoa and the U.S. Line and Phoenix Islands by CRED and partners in February/March 2003 were designed to switch from "assessment" to "monitoring" by selecting specific sites that will be resurveyed during future CRED expeditions.

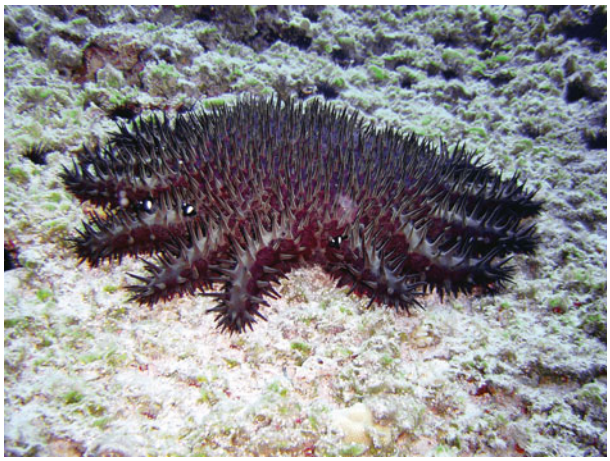
Ecological Assessment – Algae

Since summer 2003, several exciting projects have been underway in the CRED phycology laboratory. Three manuscripts describing species of red algae from the NWHI new to science have been published or sent out for review, and a manuscript documenting reproduction in one of the most common green algae in the NWHI was published. A methods paper describing CRED's quantitative algal sampling protocol was published in 2004, and several analyses have been completed using this method. The first analysis involves a detailed study of algal diversity and algal percent cover at the French Frigate Shoals (FFS), NWHI. One hundred sixty-six species of algae are now known for this area, and multivariate statistical analyses combined with other data sets reveal 7 distinct management zones at the FFS characterized by unique invertebrate and algal assemblages. The 2 other analyses represent archipelago-wide assessments of relative algal abundance in the NWHI and the Mariana Archipelago. Both studies reveal that abundance of specific algal genera changes across geographically large island groups, and these changes often reflect the

physical relationship of islands to each other. For example, instead of all of the NWHI containing a homogenous mix of algal genera, the algal floras of the northwestern-most islands in the NWHI chain are more closely related than geographically disparate islands. Laboratory work identifying algal specimens and determining percent cover continues for Pearl and Hermes Atoll, NWHI, and Howland and Baker Islands in the U.S. Phoenix Island group.

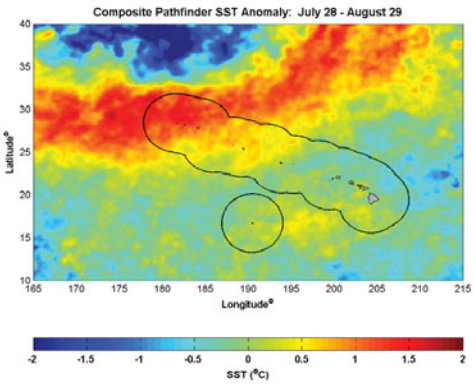
Ecological Assessment – Invertebrates

The non-coral marine invertebrate fauna of coral reefs represents a group of animals that are numerically dominant in their habitat and in some cases represent taxonomic groups that are only represented in the marine environment. New species of marine organisms are being described all the time in extensively studied habitats such as coral reefs. In addition to these new species descriptions, the expansion of knowledge concerning the ranges of known species is also an important task that is integral for the spectrum of conservation ranging from single species up to the level of ecosystems. The non-coral marine invertebrate component is conducted through a partnership between the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Center 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. The preliminary results for species richness are: 838 species from 11 phyla for the (NWHI), 395 species from 4 phyla for the Pacific Remote Island Areas (PRIA), and 507 species from 4 phyla for American Samoa. 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 results 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.



The starfish Acanthaster planci at Pearl and Hermes Reef, Northwestern Hawaiian Islands. Photo by L.S. Godwin, Bishop Museum

Oceanography



NOAA Pathfinder Sea Surface Temperature (SST) Composite Anomaly of the region of highly elevated SST implicated in the 2002 Northwestern Hawaiian Island Massive Bleaching Event. This correlates extremely well with gross patterns of documented coral bleaching (Kenyon, et. al. 2004).

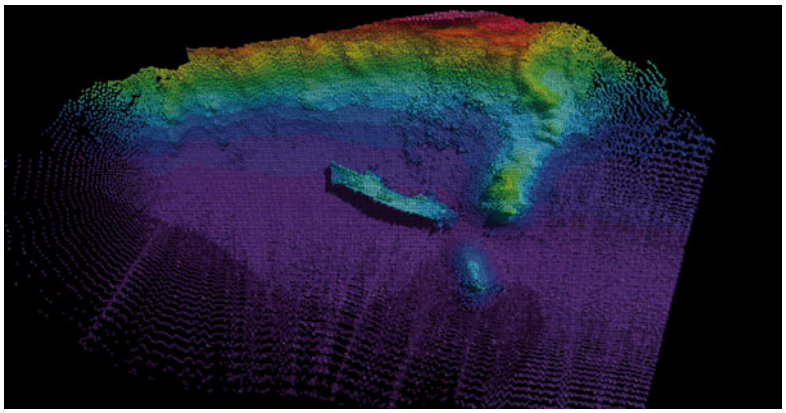
Oceanographic monitoring and assessment continues throughout the NWHI, Guam and CNMI, American Samoa, and the U.S. line and Phoenix Islands. At present, 36 sites (islands or banks) are instrumented with 21 telemetering surface buoys, providing a high-resolution time series of SST, salinity, PAR, UV-B, air temperature, barometric pressure, and wind velocity. The surface telemetered observations are augmented by a network of over 75 subsurface instruments recording water temperature, salinity, current profiles, wave, and tide data. Fourteen satellite tracked oceanic (SVPs) drifters were deployed this year, joining 36 previously deployed SVPs and vertically migrating APEX floats still being tracked. In addition, during research cruises, closely-spaced shallow water CTDs and shipboard deepwater CTDs and ADCP current profiler transects are conducted to provide a more detailed spatial (horizontal and vertical) description of ocean conditions. Within the last year, over 850 shallow water CTDs, over 90 deepwater CTDs, and approximately 12,000 kilometers of ADCP transects have further augmented the program's data collections from previous years. Integration of these datasets with the program's ecological

assessment data, as well as outside data sources, have provided insight into a number of physical/biological linkages, including:

- A high correlation of locations of upwelling EUC water with benthic habitat composition and distribution of reef fishes, in the central-equatorial region, especially at Jarvis and Baker islands.
- Extreme interannual variability of water temperatures, upwelling, and other mixing phenomena (connected with nutrient supply and primary productivity) at Jarvis and Baker and the dependence of this variability on the ENSO cycle.
- Evidence of weak but consistent upwelling along Palmyra Atoll's southern side and its connection to high biomass measured with bioacoustics.
- Lack of evidence of similar conditions at nearby Kingman Reef.
- Analysis of SVP drifters and APEX floats combined with ADCP data have demonstrated that ocean circulation patterns in the Hawaiian Archipelago are dominated by eddy variability with mean currents generally flowing from east to west, and validate a number of suspected biological connectivities, such as a suspected link between Johnston Atoll and French Frigate Shoals.
- Describing severity and observed patterns of bleaching from the NWHI 2002 bleaching event by a combination of highly elevated regional SST and restricted circulation within atolls, as well as identification of potential meteorological/climatological causal factors.

Benthic Habitat Mapping

Benthic habitat mapping of coral reefs is an important part of the 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 2002 JIMAR scientists participated in a multi-beam survey in the NWHI aboard UH's R/V Kilo Moana. Using the data collected and processed on this cruise, JIMAR, NOAA and UH scientists produced the "Bathymetric Atlas of the Northwestern Hawaiian Islands"; in 2003/4 bathymetric grids of the NWHI have been made available at http://cred.nmfs.hawai.edu/BathyAtlas. In FY 2004 a significant new mapping capability was added to this program with the delivery of a 25-ft survey launch, R/V AHI, that is equipped with a 240-kHz multi-beam sonar. Extensive mapping (755 km2 surveyed) has been conducted since July 2003 at Midway; at Saipan, Marpi Bank, Tinian, Tatsumi Reef, and Rota in the Commonwealth of the Northern Mariana Islands; in Guam; and at Tutuila, Ofu, Olosega, and Ta'u Islands in American Samoa. The figure to the right shows an image of the vessel Chehalis, an oil tanker that sank in Pago Pago Harbor during WWII. Benthic habitat maps are currently being developed from analysis of the multi-beam bathymetry and backscatter imagery data as well as of the ground-truth data collected since 2001.



Sunken vessel Chehalis in 40m water depth in Pago Pago Harbor.

Marine Debris Removal

This program also assists the immensely successful multi-agency effort to remove and recycle over 330 metric tons of derelict fishing gear from the reefs and beaches of the NWHI. Since the inception of the marine debris removal program in 1996, the three primary goals have been:

- To assess, document and remove derelict fishing gear from the coral reef environs of the NWHI down to a depth of 30 feet.
- To remove derelict fishing gear from the beaches and islands of the NWHI.
- To monitor debris accumulation in specific sites labeled High Entanglement Risk Zones (HERZ) for Hawaiian monk seals (*Monachus schauninslandi*).

Marine debris survey and collection activities from 1996-2003 were conducted at Kure Atoll, Midway Atoll, Pearl and Hermes Atoll, Lisianski Island, Laysan Island, and French Frigate Shoals.

A number of short-term ecological research projects were also implemented during the 2003 marine debris field season at Pearl and Hermes, including:

- A baseline population study of the black-lipped pearl oyster (*Pinctada margaritifera*) and the crown-of-thorns sea star (*Acanthaster planci*),
- A coral recruitment study in areas subjected to the 2002 bleaching event using settlement plate arrays,
- An ecological succession study of algal communities associated with net removal scars, and
- A study of growth rates of different corals in association with marine debris.

These studies provided additional insight into the coral reef ecology of Pearl and Hermes, along with additional insight regarding net residence times and post-removal effects.

Current year (FY 2004) operations are currently underway aboard a newly-chartered and much larger vessel (CASITAS), with 16 coral reef/marine debris specialist divers, and a field season that will run from May-October with a short 10-day break back in Honolulu in August. The effort this year will be focused on completing clean-up operations at Pearl and Hermes Atoll and then initiate debris surveys at Maro Reef.

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Appendices

Appendix I. List of Acronyms

Appendix II. Visiting Scientists

Appendix III. Seminar List

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Appendix V. JIMAR Organization

Appendix VI. JIMAR Personnel

Appendix VII. Publications Summary

Appendix I: LIST OF ACRONYMS

AAM	Asian-Australian Monsoon
ADCP	Acoustic Doppler Current Profiler
ADRM	Advection-Diffusion-Reaction Model
AGCM	Atmospheric General Circulation Model
APDRC	Asia-Pacific Data-Research Center
APEX	Autonomous Profiling Explorer
ASLO	American Society of Limnology and Oceanography
ASM	Asian Summer Monsoon
AVHRR	Advanced Very High Resolution Radiometer
AVISO	Archivage, Validation et Interpretation des donnes des Satellites Ocanographiques
BPUE	Bycatch Per Unit Effort
CLIVAR	Climate Variability and Predictability Program
CNMI	Commonwealth of the Northern Marianas
CNRS	Centre National De La Recherche Scientifique
CPUE	Catch Per Unit of Effort
CRAG	Coral Reef Advisory Group
CRED	Coral Reef Ecosystem Division
CRMI	Coral Reef Management Initiative
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity Temperature Depth
DAWR	Division of Aquatic and Wildlife Resources
DFW	Division of Fish and Wildlife
DIAS	Document Imaging Archival System
DIC	Deviance Information Criterion
DMWR	Department of Marine and Wildlife Resources
DSS	Data Server System
ECHAM	European Center-Hamburg Atmospheric Model
EEZ	Exclusive Economic Zone
ENSO	El Niño/Southern Oscillation
EOFs	Emperical Orthogonal Functions
ESA	Endangered Species Act
ESSIC	Earth System Science Interdisciplinary Center
EUC	Equatorial Undercurrent
FADS	Fish Aggregation Devices
FFS	French Frigate Shoals
FMP	Fisheries Management Plan
GAM	Generalized Additive Model
GAMS	General Algebraic Modeling System
GFDL	Geophysical Fluid Dynamics Laboratory
GIS	Global Ionospheric Studies
GLM	Generalized Linear Model
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GOES	Geostationary Operational Environmental Satellites

GPS	Global Positioning System
HCP	Habitat Conservation Program
HDAR	Hawaii Division of Aquatic Resources
HERZ	High Entanglement Risk Zones
HILLF	Hawaii Longline Fishery
HIMB	Hawaii Institute of Marine Biology
HSCO	Hawaii State Climate Office
HSP	Heat Shock Proteins
IBM	Individual Based Models
IODZM	Indian Ocean Dipole/Zonal Mode
IPRC	International Pacific Research Center
ISM	Indian Summer Monsoon
ITCZ	Intertropical Convergence Zone
JAMSTEC	Japan Agency for Marine Earth Science and Technology
JASMINE	Joint Air-Sea Monsoon Interaction Experiment
JASON	Name of a satellite (http://topex-www.jpl.nasa.gov/mission/jason-1.html)
JI	Joint Institute
JIMAR	Joint Institute for Marine & Atmospheric Research
LAS	Local Action Strategy
LBM	Linear Baroclinic Model
MARDAP	Marine Resource Dynamics and Assessment Program
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
MMPM	Multi-level, Multi-objective Programming Model
MPA	Marine Protected Area
MSA	Magneson Stevens Fisheries Conservation Act
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Center for Environmental Predictions
NEPA	National Environmental Policy Act
NetCDF	Network Common Data Format
NGO	Non-Governmental Organization
NLOM	Navy Research Laboratory Layered Ocean Model
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NOSA	NOAA Observing Systems Architecture
NTF	National Tidal Facility
NWHI	Northwest Hawaiian Islands
NWS	National Weather Service
NWSPR	National Weather Service Pacific Region
OGCM	Ocean General Circulation Model
OGP	Office of Global Programs
ORMP	Ocean Resource Management Plan
OSCARS	Ocean Surface Current Analyses - Real Time

PACS	Pan American Climate Studies
PAR	Photosynthetically Active Radiation
PATs	Pop-up Archival Transmitting Tags
PBDC	Pacific Basin Development Council
PEAC	Pacific ENSO Applications Center
PFEL	Pacific Fisheries Environmental Laboratory
PFRP	Pelagic Fisheries Research Program
PI	Principal Investigator
PICES	Name for the North Pacific Marine Science Organization
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
PMEL	Pacific Marine Environmental Laboratory
POM	Princeton Ocean Model
PRETOMA	Programa Restauracion de Tortugas Marinas
PRIA	Pacific Remote Island Areas
PSATs	Pop-up Satellite Archival Tags
SEAPODYM	Spacial Ecosystem and Populations Dynamics Model
SOEST	School of Ocean and Earth Science and Technology
SPC	South Pacific Commission
SSH	Sea Surface Height
SST	Sea Surface Temperature
TDR	Temperature Depth Recorders
TOGA	Tropical Ocean-Global Atmosphere
TZCF	Transition Zone Chlorophyll Front
UH	University of Hawaii
UHSLC	University of Hawaii Sea Level Center
UOG	University of Guam
UV-B	Ultraviolet Radiation B
VFP	Visual FoxPro
WCCW	West Coast CoastWatch
WHOI	Woods Hole Oceanographic Institution
WPacFIN	Western Pacific Fishery Information Network
WPRFMC	Western Pacific Regional Fishery Management Council

Appendix II: VISITING SCIENTISTS

July 1, 2003 to June 30, 2004

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
8/07/03 – 8/08/03	Dr. Toshiyuki Hibiya University of Tokyo	Collaborate with UHSLC researchers and Dr. Mark Merrifield and present a seminar
11/01/03 – 11/04/03	Dr. Petro Babak University of Iceland Reykjavic IS-107	Collaborate with Dr. John Sibert and two other PFRP colleagues who were attending a fishery meeting in Sete France for interview for PFRP Post-Doctoral position
11/01/03 – 11/04/03	Dr. Inna Senina Roatov State University Russia	Collaborate with Dr. John Sibert and two other PFRP colleagues who were attending a fishery meeting in Sete France for interview for PFRP Post-Doctoral position
11/16/03 – 12/12/03	Dr. Laurent Dagorn Institut De Rechervhe Pour Le Devloppement(IRD)	Collaborate with PFRP scientists and attend Principal Investigators Meeting 12/09/03 to 12/11/03; work on smart FADS project
11/21/03 – 11/27/03	Dr. Erwan Josse Centre IRD Gretagne Plouzane France	Collaborate with Dr. Kim Holland and other JIMAR Scientists on various aspects of pelagic Ecosystem research
11/23/03 – 11/25/03	Dr. Jules Jaffe University of California San Diego - SCRIPPS	Collaborate with Dr. Kim Holland and other PFRP Scientists on Fish Aggregation Devices (FADS) project
12/08/03 – 12/12/03	Dr. William K Michener Albuquerque, New Mexico	Invited speaker for the annual PFRP Principal Investigators meeting and special session on data rescue 12/9/03 – 12/11/03
12/09/03 – 12/13/03	Dr. Hiroaki Okamoto Japan National Research Institute for Far Seas Fisheries Shimizu-kusangi, Japan	Invited speaker for the annual PFRP Principal Investigators meeting and special session on data rescue 12/09/03 – 12/11/03
01/25/04 – 2/24/04	Dr. In-Sik Kang Seoul National University Seoul, Korea	Collaborate with Dr. Bin Wang and other JMAR/IPRC Scientists on investigations of the Asian Pacific Climate Variability
1/26/04 – 2/27/04	Dr. Kyung Chin Seoul National University Seoul, Korea	Collaborate with Dr. Bin Wang and other JIMAR/IPRC Scientists on ENSO

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
2/15/04 – 3/20/04	Dr. Jong-Seong Kug Seoul National University Seoul, Korea	Collaborate with Dr. Fei Fei Jin and other JIMAR and Meteorology Dept. Scientists; invited to participate in project related to ENSO Dynamics and Prediction
2/18/04 – 2/20/04	Dr. B. N. Goswami Centre for Atmospheric and Oceanic Studies Indian Institute of Science	Participate in the International Asian Monsoon Symposium(IAMS) at the East-West Center 2/18/04 – 2/20/04
2/18/04 – 2/20/04	Dr. Sulochana Gadgil Centre for Atmospheric and Oceanic Studies Indian Institute of Science	Participate in the International Asian Monsoon Symposium(IAMS) at the East-West Center 2/18/04 – 2/20/04
2/18/04 – 2/20/04	Dr. Tseng-Chang (Mike) Chen Iowa State University Ames, Iowa	Participate in the International Asian Monsoon Symposium(IAMS) at the East-West Center 2/18/04 – 2/20/04
3/09/04 – 3/13/04	Dr. Masahiro Watanabe Hokkaido University Sapporo, Japan	Collaborate with Dr. Fei Fei Jin and other JIMAR and Meteorology Scientists and researchers
4/12/04 – 4/18/04	Dr. Annie Wong University of Washington Seattle, WA	Collaborate with Department of Oceanography researchers and JIMAR Scientists and present a seminar

Appendix III. SEMINAR LIST

July 1, 2003 to June 30, 2004

DATE	NAME/AFFILIATION	TITLE
08/08/03	Dr. Toshiyuki Hibiya University of Tokyo Graduate School of Science Tokyo, Japan	Global Mapping of diapycnal diffusivity in the deep ocean based on fine-scale vertical shear measured by expendable current profilers
04/13/04	Dr. Annie Wong University of Washington Pacific Marine Environmental Laboratory Seattle, Washington	Eastern Subtropical Mode Water in the South Pacific and Application of ARGO Data in Ocean Climate Studies

Appendix IV. WORKSHOPS AND MEETINGS HOSTED BY JIMAR

July 1, 2003 to June 30, 2004

PELAGIC FISHERIES RESEARCH PROGRAM PRINCIPAL INVESTIGATORS MEETING 2003

December 9, 2003 to December 11, 2003

Allain, Valerie
Allen, Stewart
Amesbury, Judy
Anderson, Angela
Bartram, Paul
Beeching, Tony
Betts, Arthur
Bigelow, Keith
Billig, Pricilla
Boido, Alohalani
Bolker, Ben
Brainard, Rusty
Brill, Richard
Curran, Dan
Dagorn, Laurent
Firing, June
Fromentin, Jean-Marc
Fry, Brian
Gough, Amy
Graham, Brittany
Griesemer, Adam
Grubbs, Dean
Hamm, David
Hawn, Donald
Holland, Kim
Howell, Evan
Huang, Hui
Humphreys, Bob
Hyder, Patrick
Itano, David
Kaneko, John
Kikkawa, Bert
Kleiber, Pierre
Labelle, Marc
Lawson, Tim
Leung, PingSun
Lindstrom, Daniel
McNaughton, Lianne
Meyer, Carl
Michener, Bill
Moffitt, Russ
Morioka, Roy
Moyes, Chris
Musyl, Michael
Nemoto, Keiichi
Nishimoto, Robert
Okamoto, Hiroaki
Olson, Bob
Pan, MinLing
Papastamatiou, Yannis
Parker, Joan
Polovina, Jeffrey
Pooley, Sam
Popp, Brian
Pradhan, Naresh
Royer, Francois
Schultz, Jennifer
Seki, Michael
Sibert, John
Southwood, Amanda
Swimmer, Yonat
Walsh, Bill
Ward, Peter

Appendix V. JIMAR ORGANIZATION

Senior Fellow Roster	Term Expires
NOAA	
Dr. Eddie Bernard	03/31/2005
Dr. Richard Brill	10/31/2004
Dr. Ed Harrison	06/30/2005
Dr. Gregory Johnson	12/31/2004
Dr. William Kessler	06/30/2005
Dr. Michael Laurs	10/31/2004
Dr. Frank Marks, Jr.	08/30/2006
Dr. Michael McPhaden	06/30/2005
Dr. Dennis Moore	06/30/2006
Dr. Jeffrey Polovina	11/30/2004
Dr. Mark Powell	08/31/2006
Dr. Frank Schwing	06/30/2005
University of Hawaii	
Dr. Gary Barnes	08/31/2006
Dr. Steven Businger	10/31/2004
Dr. Eric Firing	03/31/2005
Dr. Charles Fletcher, III	12/31/2004
Dr. Roger Lukas	03/31/2005
Dr. Douglas Luther	10/31/2004
Dr. Julian McCreary	12/31/2004
Dr. Mark Merrifield	12/31/2004
Dr. Thomas Schroeder	10/31/2004
Dr. John Sibert	10/31/2004
Dr. Bin Wang	06/30/2005
Visiting Senior Fellows	
Dr. Gerald Meehl	10/31/2004
Dr. Jagadish Shukla	10/31/2004
Dr. Akimasa Sumi	10/31/2004
Dr. Michio Yanai	10/31/2004

JIMAR Council Members	
NOAA	
Dr. Michael McPhaden	12/31/2004
Dr. Dennis Moore	12/31/2004
Dr. Jeffrey Polovina	12/31/2004
University of Hawaii	
Dr. Eric Firing	12/31/2004
Dr. Julian McCreary	12/31/2004
Dr. Thomas Schroeder	(ex officio)
Dr. Bin Wang	12/31/2004

Appendix VI. JIMAR PERSONNEL

Information as of June 30, 2004

Category	Number	Unknown	High School	Associates	Bachelors	Masters	Ph.D.
Research Scientist	18	0	0	0	0	2	16
Visiting Scientist	2	0	0	0	0	0	2
Postdoctoral Fellow	8	0	0	0	0	0	8
Research Support Staff	90	2	3	3	53	25	4
Administrative	11	0	1	1	8	1	0
Undergraduate Students	18	0	18	0	0	0	0
Graduate Students*	14	0	0	0	9	3	2
Received less than 50% NOAA support	13	0	2	0	2	0	9
Total	**174**	**2**	**24**	**4**	**72**	**31**	**41**
Located at Lab (include name of lab)	2 - PMEL						
Obtained NOAA employment within the last year	4						

*2 Graduate Students pursuing another Ph.D. degree.

Students and postdocs (for the period 7/1/03 thru 6/30/04):

	Associated with NOAA Funded Research	Received NOAA Funding
Undergraduate Students	31	28
Graduate Students	41	41
Postdocs	10	10
Total	82	79

Appendix VII. PUBLICATIONS 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	FY02	FY03	FY04	FY02	FY03	FY04
Peer-reviewed	19	18	36	7	33	22	17	20	30
Non-peer-reviewed	15	16	39	15	10	17	10	14	21