

2003 Annual Report for Cooperative Agreement NA17RJ1230

Celebrating 25 Years of JIMAR

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Annual Report for Fiscal Year 2003

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Introduction

he 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 through the Southwest Fisheries Laboratory. 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.



Thomas Schroeder Director

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.

FY 2003 coincided with JIMAR's 25th Anniversary. A celebration was held during the January visit to Honolulu by the OAR Senior Research Council (SRC). The SRC meeting was jointly hosted by JIMAR and its sister OAR/UH partners the Hawaii Sea Grant College Program and the Hawaii Undersea Research Laboratory. The highlight was a reception at the UH Presidential residence (College Hill) hosted by President Evan Dobelle.

The most significant developments for FY 2003 were the additions of new resources to the NOAA and University of Hawaii fleets. The FV *Oscar Elton Sette* joined the National Marine Fisheries Service (NMFS) Hawaii fleet and the RV *Kilo Moana* joined the University fleet. Both are based at the UH Marine Center. Both have already served as venues for JIMAR research missions.

There have been other significant changes in the Hawaii elements of fisheries research. A Pacific Region of NMFS has been established. Resulting realignments of laboratories and responsibilities for financial transactions should improve our excellent collaborations with NMFS. NMFS, JIMAR (Pelagic Fisheries Research Program) and the School of Ocean and Earth Sciences and Technology (SOEST) have combined to seed the development of a graduate program in Tropical Fisheries and Aquaculture at UH. A specialist has been recruited to design and implement this nascent program.

Coastal research has grown rapidly especially in the areas of coral reefs and health of coastal ecosystems. The focus of research is the Northwest Hawaiian Islands. In this report we show graphic evidence of the concerns surrounding the coasts of these islands.

Our climate programs have continued to expand. The collaboration between JIMAR and the International Pacific Research Center has continued to grow. In addition to the Asia-Pacific Data Research Center, IPRC scientists are more and more active in other JIMAR climate programs. 2002-2003 was an El-Nino Southern Oscillation (ENSO) warm event and the Pacific ENSO Applications Center responded superbly, replicating our performance of 1997-1998 which drew widespread praise.

Lastly, current and past JIMAR scientists have received rocogntion internationally and locally. We were informed this past spring Professor Emeritus (and Senior Fellow) Klaus Wyrtki was awarded Prince Albert Medal by the International Association for the Physical Sciences of the Ocean (IAPSO). This was presented to Prof. Wyrtki at the International Unions of Geodesy and Geophysics assembly in Sapporo, Japan in July 2003. On a comparatively minor note, Director Thomas Schroeder was recognized as a Distinguished Alumnus of the School of Science at Purdue University. This award was presented in April 2003.

This report represents the first significant format change in the JIMAR Annual Report. We are adding illustrations and some color. We are benefitting from the services of Diane Nakashima who has been loaned to JIMAR by SOEST to assist us in modernizing our products.

ACCOMPLISHMENTS FOR FISCAL YEAR 2003

EQUATORIAL OCEANOGRAPHY

The University of Hawaii Sea Level Center

P.I.: Mark Merrifield

Purpose of Project

The University of Hawaii Sea Level Center (UHSLC) collects, processes, and distributes tide gauge data from around the world in support of various climate research activities. The measurements are used for the evaluation of numerical models (e.g., those in operation at NCEP), joint analyses with satellite altimeter datasets, the calibration of altimeter data, the production of oceanographic products through the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Sea Level Program in the Pacific (SLP-Pac), and research on interannual to decadal climate fluctuations and long-term trends. In support of satellite altimeter calibration and validation and for absolute sea level rise monitoring, the UHSLC and the Pacific GPS Facility maintain co-located GPS systems at select tide gauge stations (GPS@TG). We are also working with other groups associated with the global observing system to provide syntheses of various datasets and to compile and distribute associated products.

Progress During FY 2003

Climate Research

Interannual and decadal changes and sea level rise have been our primary research focus areas during FY2003. A manuscript describing decadal oscillations in sea level in the eastern Pacific is nearly ready for submission. We have described how the long sea level record collected at the Honolulu tide gauge is connected to Pacific North America (PNA) related fluctuations in winds and surface pressure. Possible heat flux contributions to this signal are being examined as nearly one-half of the decadal variability in sea level is contributed by heat changes in the upper 60m of the water column.

As part of our commitment to provide absolute sea level estimates at selected sites, we are examining signal-tonoise ratios that limit the accuracy of GPS-derived ground motion rates. By identifying and removing noise from the data, we hope to reduce the time necessary to resolve absolute sea level trends of the order of 1 mm/year. We have collected bottom pressure data from around the Hawaiian Islands and are we are now investigating whether oceanic loading signals at low frequencies contribute to the GPS variations on the islands. Preliminary results are encouraging.

We are finishing our case history of sea level variability and sea level rise at the Funafuti atoll in Tuvalu. Reports of flooding due to global sea level rise have appeared in the popular press. The UHSLC maintained a station at Funafuti for nearly 20 years, which is now being extended forward by the National Tidal Facility, Australia. We find that annual extrema have increased more rapidly than annual mean sea level, suggesting that flooding occurrences are tied to changes in weather patterns near the island rather than eustatic sea level rise.

A study of island sinking rates along the Hawaiian island chain is nearing completion. Differences in sea level rise rates recorded at Hilo and Honolulu have long been attributed to variable subsidence rates associated with volcanic activity. Continuous GPS measurements indicate that the rates are more similar between the islands. We are investigating whether the sea level rate difference may be due in part to steric variations associated with large-scale wind patterns.

We continued to work with NOAA's Pacific Marine Environmental Laboratory (PMEL) and the NODC to support the Climate Data Portal (CDP), consisting of a networked system connecting diverse, distributed servers at PMEL (TAO El Nino buoys), UHSLC, and NODC (the Global Temperature-Salinity Profile Program or GTSPP dataset). The CDP enables researchers and others to access the products developed by the various elements of the ENSO Observing System over the Internet without having to log on to multiple web sites. The technology developed in this project ultimately may be useful for other NOAA servers in an operational sense. This program has also produced ncBrowse, a graphical netCDF file browser that can be used to preview the UHSLC CLIVAR/GLOSS fast delivery dataset.

The CLIVAR/GLOSS dataset was added to the National Virtual Ocean Data System (NVODS). Our participation in the NVODS is to promote wider dissemination of UHSLC products and to stay current with evolving distribution strategies. Given our existing infrastructure, we were able to implement this task without significant expense to the project. To add this dataset to the NVODS, netCDF files were developed and an OpeNDAP server for these files installed at the UHSLC.

Tide Gauge Network Operations

The UHSLC operates 37 tide gauge stations in the global sea level network and collaborates with host countries in the operation of seven more stations. Station maintenance during FY2003 included site visits to Settlement Point, where the tide gauge and GPS were relocated due to harbor construction, and Johnston Atoll and Hanimadoo where new equipment was installed. Routine service trips were made to Port Louis, Rodrigues, Point LaRue, Zanzibar, Mombasa, Lamu, Santa Cruz, French Frigate Shoals, Cape Verde, Saipan, Malakal, Hulele, and Baltra. Stations that developed problems that our technicians were able to solve remotely during FY 2003 included Cape Verde, Esperanza, Easter Island, Manzanillo, Port Louis, and Cabo San Lucas. During a maintenance visit to the western Indian Ocean, we conducted site reconnaissance visits at Madagascar and Aldabra in anticipation of an expansion of our African network.

The UHSLC provided partial support for a visit by Charles Magori of Kenya to discuss the feasibility of establishing a coordinated sea level network in Africa. Mr. Magori has assisted us in the operation of our two Kenyan stations, and he is well placed to lead a regional effort. Several operational models were discussed with the most likely outcome being three regional centers covering Eastern, Western, and Southern Africa (Magori would direct the Eastern Africa center). In this model, the UHSLC would provide technical support for all three centers and conduct regular maintenance visits to ensure network stability and data quality. During Magori's visit, UHSLC sea level processing and analysis techniques were discussed. Mr. Magori has submitted a proposal for the African Sea Level Network to international aid agencies. He is awaiting the review of that proposal. If successful, UHSLC participation would be covered by this funding source.

Products and Datasets

The UHSLC and NODC collaborate to maintain the Joint Archive for Sea Level (JASL), which is a quality assured database of hourly sea level from selected stations from around the world. In the past year, the UHSLC increased its JASL holdings to 9213 station-years, including 5103 station-years at the 195 Global Sea Level Observing System (GLOSS) sites. Of the 101 GLOSS stations that are presently operating on islands, 93 are available through the JASL. The 2002 submission of the JASL data to the World Data Center-A for Oceanography included 105 series that contained measurements through the year 2001.

The UHSLC maintains a fast delivery database in support of various international programs (e.g., the Global Ocean Data Assimilation Experiment - GODAE, CLIVAR). To ensure active participation and coordination with the international community, the database has been designated by the International Oceanographic Commission as a component of the GLOSS program. The fast delivery data also are used extensively by the altimeter community for ongoing assessment and calibration of satellite altimeter datasets. In particular, fast delivery data are used for monitoring the latest JASON altimeter and for the tie between JASON, TOPEX/Poseidon, ERS, and GEOSAT satellites. The fast delivery sea level dataset now includes 141 stations, 113 of which are located at GLOSS sites.

During FY2003, the UHSLC continued development of a quasi-real time dataset of hourly (collection + up to a three hour delay, H-3 delay) and daily filtered values (J-2 delay) in support of GODAE. Approximately 50 stations currently are available in real-time with plans for ongoing expansion. We will distribute this product through our web site, and make it available in a netCDF format via an OPeNDAP server.

The UHSLC helped construct the WOCE V3 DVDs that was distributed in November 2002. UHSLC also produced CDROMS that were distributed with the JASL annual data report. These CDROMS are shared with all data originators and sent to other users upon request. Over 100 were distributed last year.

As part of the JCOMM SLP-Pac, the UHSLC operates a Specialized Oceanographic Centre that produces sea surface topography maps (monthly) and diagnostic time series (quarterly) for the Pacific Ocean. This activity is a continuation of one of the earliest examples of operational oceanography. The UHSLC presently distributes these products through the Internet and by mail to users. The net result is that approximately five weeks after the end of a

month, hundreds of users throughout the world receive an analysis of the state of the Pacific Ocean sea surface topography for that month. The analysis includes comparisons of tide gauge and altimeter sea surface elevations that are available through the UHSLC web site (uhslc.soest.hawaii.edu).

Conferences, Meetings, and Working Groups

In July 2002 we attended the Western Pacific Geophysics Meeting in Wellington, New Zealand, where we chaired a session and presented three papers, one jointly with PMEL and NODC.

In the late summer of 2002, we served on the National Oceanographic Partnership Program Ocean.US Applications and Products Expert Team. This group of experts were tasked with defining the roles and responsibilities of the IOOS DAC to provide and distribute products generated not only by the DAC but also by other elements of the U.S. IOOS or contributed by external providers, and incorporating this information in a Phased Implementation Plan for the U.S. Integrated Ocean Observing System.

In September 2002, utilizing GLOSS resources, we visited the Directoria de Hidrografia e Navegacao da Marinha (DHNM) of Brazil. There were several objectives: 1) to acquire historic holdings of hourly sea level data for GLOSS locations, 2) to share expertise in data processing, 3) to make plans for future data exchange, and 4) to learn about the most suitable locations for installation of University of Hawaii Sea Level Center station(s).

In October 2002 we participated in the NOAA sponsored Regional workshop on Potential Applications of Ocean Observations for the Pacific Region in Nadi, Fiji, where we made a presentation on sea level rise at Tuvalu and participated in various working groups. We also served at the concurrent meeting of the Pacific GOOS Steering Committee.

Also in the fall of 2002, the UHSLC conducted an inventory of its observation systems as part of the NOAA Observing Systems Architecture (NOSA) via the NOAA Forge online system. This will allow the UH sites to be part of the NOAA Program Review Team (PRT) Process.

In October 2002 we participated in the Jason-1 Science Working Team meeting in New Orleans and presented a poster on our CGPS network measurements.

In November 2002 we attended the WOCE & Beyond Conference in San Antonio, where we distributed and helped demonstrate the WOCE V3 DVDs and the ncBrowse package.

In March 2003 we participated in a Roundtable of Federal Hazard Mitigation Partners in the Pacific Islands in Honolulu, where we presented an update on extreme sea level events in the Pacific region.

In April 2003, utilizing GLOSS resources, UHSLC JASL coordinator, Pat Caldwell was one of three faculty in the GLOSS Training Course held at the Servicio de Hidrografia y Oceanografia de la Armada in Chile. Participants were from Spain, Cuba, Mexico, Panama, Venezuela, Peru, Brazil, Argentina, and Chile. The emphasis was on the use of the UHSLC Processing Software for IBM-PC Compatible Microcomputers. He also visited the Direccion de Hidrografia y Navegacion (DHN) of Peru. The primary focus was on corrections of level jumps in historic data and to secure future data exchange. Pat also represented the GLOSS at the International Hidrographic Organization (IHO) Committee on Tides conference held in Lima on April 23, 2003. The purpose was to initiate a dialog between the IHO and GLOSS.

In May 2003 we participated in the Climate Observation Program Workshop at Silver Springs. A poster was presented on the activities of the UHSLC.

Penetration of Anthropogenic CO₂ 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

Purpose of the Project

Developing a new method for estimating the penetration of anthropogenic CO_2 in the oceans. The objective of this task I to include the variable remineralization ratios for estimating the anthropogenic CO_2 inventory in the ocean.

Progress During FY 2003

Empirical equations for the preformed alkalinity and preformed nutrients in three major oceans are obtained. The preformed alkalinity is a necessary parameter to estimate the anthropogenic CO_2 in the ocean.

Support of Shipboard ADCP Work During GASEX-II Project

PI: Eric Firing

Purpose of the Project

To perform final processing and archiving of shipboard ADCP data from the GASEX-II cruise of the NOAA Ship Ron Brown, which took place early in 2001 in the eastern equatorial Pacific.

Progress During FY 2003

Through work with other Ron Brown data sets, a refinement of the processing was developed and applied to the GASEX data set. The ADCP data have been archived by the NODC Joint Archive for Shipboard ADCP (JASADCP).

TSUNAMI RESEARCH

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

P.I.: Douglas S. Luther

Purpose of the Project

Our purpose is to acquire and archive, in an electronically accessible location, a database of high quality, rapidlysampled 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 Islands 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 2003

The Archive of Rapidly-Sampled Hawaiian Sea Level (ARSHSL) is being maintained on the World Wide Web (WWW address: ftp://ilikai.soest.hawaii.edu/arshsl/techrept/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 six NOS and 15 PTWC gauges dispersed around the five main islands of Hawaii (this represents a loss of one gauge, at Mahukona on the Big Island, which was destroyed by high surf in August, 2002, and will not be replaced). 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 unre-

stricted, e.g., several NSF-funded programs are utilizing ARSHSL's data to study phenomena around the Hawaiian Is. 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 this past year required more effort than normal due to gauge failures and network interruptions beyond our control. Data from the most problematic gauges, those that transmit their data via microwave links to PTWC, are plotted bi-weekly and provided to PTWC to aid their diagnosis of gauge faults. As problems have developed with other gauges, we have provided diagnostic information to PTWC or NOS, as appropriate, in order to promote maintenance activities. Unfortunately, while PTWC and NOS personnel are always helpful, lack of resources has meant long delays in repairing broken gauges. This problem remains a deterrent to maximizing the archive's data holdings.

CLIMATE RESEARCH

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

P.I.: Thomas Schroeder

Purpose of the Project

Almost nine 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 the UH and the NOAA/NCEP/Climate Prediction Center (CPC) in research on experimental climate prediction, primarily rainfall prediction. Social scientists at UH, UOG and the PBDC conduct research on impacts of interannual climate variability on the economies, cultures and public health of the U.S.affiliated Pacific Islands (USAPI). Recently scientists from the East-West Center have collaborated with PEAC.

Progress During FY 2003

PEAC offers a quarterly newsletter and maintains a website which contains climatological data and PEAC research results as well the newsletter text. Our scientists continue to examine the details of climate variability for each country or state. We routinely appear at regional meetings to discuss our findings and implications

for the various entities. Through the NWSPR we continue to interact with the CPC and have shared our experience with scientists at the International Research Institute for Climate Prediction (IRI). The Center's effort have been well received throughout the Pacific to the extent that we have been routinely approached by non-U.S. affiliated governments asking us to replicate our efforts for their countries.

We are at the end of our second significant warm event, the previous being the 1997-1998 major event and subsequent cold event. In each instance PEAC has reacted rapidly to developments.

The Center has been in a prolonged transition. After initial OGP support ended the UH/JIMAR component was supported through the NWSPR at a reduced level. Support for PEAC now is provided through the Climate Observations and Services initiative within NOAA.

With this support we have been able to recruit a new applications scientist and anticipate the arrival of a NOAA Corps officer in the coming year.

Hurricane Iniki at Landfall, 1530 Hawaiian Standard Time September 11, 1992. Iniki is the greatest natural disaster in economic terms in the history of the State of Hawaii. JIMAR's tropical meteorology theme includes substantial effort in understanding all aspects of hurricanes.

Coupled Dynamics of Climate State Asymmetry and ENSO

P.I.: Fei-fei Jin

Purpose of the Project

A novel paradigm has also been proposed to describe the formation of both the Pacific cold-tongue climate state and ENSO in a unified coupled dynamic framework. Zonally asymmetric coupling among the Walker circulation, warm pool/cold tongue SST contrast, and upper ocean heat content, together with the recharge oscillation mechanism, are responsible for the two striking aspects of the tropical climate system. In collaboration with Vaart and Dijkstra of Netherlands, we have extended the simple model study of the Pacific cold tongue and ENSO to an intermediate coupled model. This fully coupled Cane-Zebiak type model produces both the coupled cold tongue and ENSO and verifies the basic results obtained in the simple model.

Progress During FY 2003

We investigated the impacts of climate state changes on decadal to interdecadal scale on ENSO. We also developed a theoretical model for the mechanisms of interdecadal climate variability of the North Pacific oceanatmosphere system. We also identified an unique nonlinear process which may be important for the decadal amplitude modulations of ENSO and also examined an new concept about ENSO-regime predictability.

We studied nonlinear heating associated with ENSO using NCEP data and found the nonlinear heating is important for generating strong 82-83 and 97-98 El Ninos. The nonlinear heating from ENSO also changes the climate mean state. We also found that there is fast coupled mode in the tropical Pacific. These fast mode is of near periodicity and has strong activity during La Ninos. We also investigated the ocean biological feedbacks on ENSO.

We have further investigated the existence of the near annual coupled mode in the tropical Pacific. We have accomplished most objectives of the project.

A Study of Ocean-Atmospheric Interaction in the Atlantic

P.I.: Fei-fei Jin

Purpose of the Project

This project is to investigate the mechanisms of the decadal variations in the both north and tropical Atlantic and the roles of the ocean-atmosphere interaction in shaping the structures and selecting time scales of the decadal variability. Specifically, we will address the following issues: (i) the processes shaping the patterns of the anomalies in the sea surface temperature (SST) and in the associated atmospheric circulation of the Atlantic decadal variability, (ii) the relative importance of the oceanic advection, gyre circulation adjustment, and thermohaline circulation adjustment for determining the decadal time scale of the quasi-cyclic variability, and (iii) the impacts of the remote (e.g. ENSO) and local (weather noise) external forcing on the Atlantic decadal variability.

We proposed to carry out theoretical analyses and numerical modeling. Firstly, we will develop a linearized steady atmospheric model and use it to study the excitation of the NAO pattern by SST anomalies in the north and tropical Atlantic. Secondly, we will couple this atmospheric model to three oceanic models, a 1.5-layer ocean model with embedded mixed layer for SST variations, a linearized version ocean general circulation model (OGCM), and a full OGCM. We will perform eigen-analysis for the first two versions of coupled models and explore the dependence of the structure, growth rate and frequency of leading coupled modes on various processes and parameter regimes. Finally, we will further include weather noise and other forcing to study the excitation of the decadal modes in our coupled models and compare the simulated decadal variability with observed structure and evolution of both tropical and north Atlantic decadal variability.

Progress During FY 2003

In the second year of the proposal, we have been working on the development of parameterization for interactions between storm truck activity and low frequency atmospheric circulation. We derived an explicit formulation for the synoptic eddy and low-frequency flow (SELF) feedback operator. This has been the most difficulty subject for decades and we have now not only established the closure but also validated with the observation in both barotropic and 5-(and 11-) level primitive equation model. We also showed for the first time that NAO and associated transient eddy anomalies over the Atlantic are two related parts of an internal dynamic mode that is the leading mode of our linear dynamic operator with SELF feedback. This is the most significant result of the second year project.

We have performed singular vector analysis, forced experiments with tropical and middle latitude forcing. We are now coupling the linearized primitive model with the SELF feedback to a simple upper ocean model. We expect that the observed dominating SST pattern and its association with NAO will become again two related parts of a leading mode of the coupled system. We thus will be able to finish the major part of the Step 2 of the project. We are also hopeful to carry out a part of Step 3 of the project in the third year. Because we have encountered the very exciting development in solving the difficult problem of the SELF feedback, some parts of the project in step 2 and step 3 will be more likely finished by extending this project for another funding cycle. The outcome of the project is, however, among the most significant ones of the PI' past projects in the sense that we have made a significant contribution in terms of understanding the origin and thus the basic dynamics of NAO. In the third year, we may make further contributions to understand the coupled dynamics of the NAO and Atlantic SST patterns.

Dynamics of Pacific Decadal Climate Variability and ENSO Modulation

P.I.: Fei-Fei Jin

Purpose of the Project

Significant decadal variations in the Pacific have been identified together with evidence of the strong decadal modulations of the frequency, amplitude and predictability of El Niño-Southern Oscillations (ENSO). Our understanding of the decadal variability is still limited. The aim of this proposed research focuses on the roles of the tropical oceanatmosphere interaction in the decadal climate variations of the tropical Pacific and decadal modulations of ENSO. Particularly, we will examine the relevance of the decadal modes (recently found as analytical solutions of a reducedgravity model by the PI) of tropical ocean dynamics to the decadal climate variability of the tropic Pacific. We will investigate the coupled mechanisms that modify the decadal modes of the tropical ocean into coupled modes. We will study the interaction of the coupled decadal modes with ENSO and explore nonlinear scenarios, which allow large amplitude modulations of ENSO. We will also explore the implications of these deterministic processes to the regime predictability of the ENSO activity.

Progress During FY 2003

We continued our study of the tropical coupled decadal mode with intermediate coupled mode. We found that in addition to an interannual coupled mode that resembles ENSO, there is an independent coupled decadal mode that is also originated in the tropics with similar mechanisms as for ENSO mode. This paper is submitted for publication and currently in revision.

We worked on further about the nonlinear scenario that we proposed for the decadal amplitude modulations of ENSO. This work will be highlighted in *AMS Bulletin*.

We study the impact of the SST anomalies in the western Pacific warm pool region on the ENSO cycle.

We studied the decadal warming in the tropical Pacific and its relations with the enhanced ENSO activity. Since the changes in ocean background conditions in the last few decades could have been responsible for the change in the ENSO activity, our result suggests a possible nonlinear positive feedback between mean climate change and ENSO variability. The potential positive feedback between climate mean state change and ENSO variability is worth for further study. This work is to be presented in AMS meeting and to be published in GRL. It is also going to be highlighted in AMS Bulletin.

We are further improving the linearized atmospheric model. We have made some significant progress in including the transient eddy feedback on the mean-flow in this linear steady model. A series of papers on this work is about to be submitted for publication. In this work, we developed an innovative and general way to determine the dynamic feedback among the mean flow and transient eddies. This has been one of the most difficult problems in the quest to understand the dynamics of the low frequency variability of the atmospheric circulation. We now have derived a new dynamic framework of a quasi-steady and linearized dynamics system for the general circulation with parameterized effect of transient baroclinic eddy feedback. We will couple this model with both intermediate and MOM3 models in the rest of the project period to study the Pacific decadal variability.

Effects of the Andes on the Eastern Pacific Climate

P.I.: Shang-Ping Xie and Yuqing Wang (co-PI)

Purpose of the Project

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

Progress During FY 2003

A high-resolution (0.5 deg) regional atmospheric model (RAM) is configured for the eastern Pacific Ocean and run under both the warm (March-April) and cold (August-October) conditions. The presence of the high Andes is to enhance the low cloud deck off the west coast of South America in the cold season and prolong the southern inter-tropical convergence zone in the warm season. Both effects of the Andes are to increase the climatic asymmetry and help keep the eastern Pacific north of the equator. We also carried out related studies to better understand the air-sea interaction on the equatorial front by analyzing the EPIC enhanced buoy measurements and modeling the atmospheric co-variability with oceanic tropical instability waves. A major result is that the atmospheric hydrostatic pressure effect is very important in the atmospheric adjustment to changing SST, shedding new light on coupled tropical instability waves.

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

P.I: Shang-Ping Xie

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 2003

Two major studies have been carried out toward this goal. First, an atmospheric GCM is coupled with an intermediate ocean model to study the effect of land-sea distribution on the mean state and climate variability. The northward displacement of the oceanic ITCZ, trigged by the continental asymmetry on the eastern continent, reduces the strength of air-sea interaction in the meridional direction, a mechanism that may explain the weak correlation of SST between the hemispheres in the tropical Atlantic. In the second study, an atmospheric GCM is used to study the interaction between the Atlantic equatorial cold tongue and African monsoon. The onset of strong southerly cross-equatorial winds as part of the African monsoon triggers the seasonal development of the equatorial cold tongue, with the local air-sea interaction in the equatorial Atlantic also playing an important role.

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

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

Purpose of the Project

JASMINE is 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 upperocean, air-sea flux and atmospheric data sets focusing on the onset phase of the southwest monsoon and its subsequent evolution over the seasonal cycle. The analysis phase focuses on the active and break period variability associated with the intraseasonal oscillations, and begins to determine to what extent these features represent a coupled, predictable phenomenon. The ocean component (UH) has 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. In addition, JASMINE data has been used to help plan a program of sustained observations and future process studies in the Bay of Bengal sector of the Indian Ocean.

Progress During FY 2003

The primary focus of our work has been the completion of the ocean input to the overview paper on the JAS-MINE fieldwork and results. In addition, we have continued our research and analysis with focus on the ocean component goals, and have used our JASMINE observations as input to international planning efforts for the design of monitoring activities and process studies in the Indian Ocean as part of the "First Conference of the Indian Ocean Global Ocean Observing System, IOGOOS" held in Grand Bay, Mauritius, November 1-9, 2002.

Establishment of a Data Research Center for Climate Studies

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

Purpose of the Project

The project implements the establishment of the Asia-Pacific Data-Research Center (APDRC) within the International Pacific Research Center (IPRC) at the UH. 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/GFDL to implement infrastructure in support of the Global Ocean Data Assimilation Experiment (GODAE).



Sunlit cumulus clouds beneath an anvil cloud over Oahu. Photo by Steve Businger.

Progress During FY 2003

A primary focus over the past year has been the continuing development of the Data Server System (DSS) with NOAA/PMEL and upgrading the web access to products at http://apdrc.soest.hawaii.edu. The site is currently serving both local and remote, and gridded and *in situ* data from Live Access Servers and EPIC servers developed at NOAA/PMEL, and from OPeNDAP (formerly DODS) and GrADS/DODS servers. The site also has new links to partner sites, and shows usage statistics for the servers. A second focus has been on archive building and data management of the served data sets and products. The major accomplishment has been the serving of the World Ocean Circulation Experiment (WOCE) data set released in November 2002 and a test site serving the global Argo data set. In addition, we have initiated a subcontract with CSIRO in Hobart, Australia for the quality control of the historical upper ocean thermal data set for the Indian Ocean, and have begun a funded collaboration with JAMSTEC, Japan on data server development and data management for climate models. Collaboration has focused on the development of plans for Argo regional centers for the Pacific and Indian Oceans, and international coordination on data serving and product development addressing the needs of the Climate Variability and Predictability Programme (CLIVAR) and GODAE.

Remote Forcing on the US Warm Season Rainfall and the Eastern Pacific Climate

PI: Bin Wang, Tim Li and X. Fu

Purpose of the Project

The purpose of the project is to improve our understanding of a) the formation of the mean climate and annual cycle of the eastern Pacific, and b) physical processes that control US warm season rainfall variability. The unified theme focuses on impacts of the remote forcing on the regional climate over the eastern Pacific and North America. These endeavors are important for improving regional climate modeling and prediction in the eastern Pacific and United States.

Proposed tasks include a) investigation of the impacts of continental monsoons on the mean climate and annual cycles in the eastern Pacific, and b) study of the physical processes that link US warm season rainfall anomalies and the anomalous forcing from remote western North Pacific.

Progress During FY 2003

Study of the impacts of the monsoons on eastern Pacific climate

Our proposed study of the adjacent and remote continental monsoons on the eastern Pacific mean climate and its annual cycle is a unique new project within the PACS. In particular the study of the remote Asian-Australian monsoon on the eastern Pacific climate is a pioneer work.

This investigation has been completed using an intermediate coupled model. It is found that the Asian-Australian monsoons influences the climatological mean tropical Pacific SST and the equatorial thermocline slope through changing the mean strength of monsoon and trades in the western Pacific. They are responsible for producing a correct semiannual cycle of surface wind speed in the western equatorial Pacific, which is essential for the generating the SST semiannual cycle in this region. However, the Asian-Australian monsoon has little influence on the eastern Pacific SST annual cycle. In contrast the role of the Asian-Australian monsoon, the American continental monsoons affect primarily the eastern Pacific SST annual cycle, but not the climatological mean SST. The South American monsoon exerts profound impacts on the annual variations of the southeast trades in the east Pacific, which is shown to be an important external forcing of the SST annual cycle in the eastern equatorial Pacific. However, the Columbian and Central and North American continental monsoons have little impact on the annual cycle of SST in the Cold Tongue.

Research tools developments: Coupled GCM and regional climate models

The intermediate coupled atmosphere-ocean model has been a very useful tool for study of the eastern Pacific mean climate and annual cycle and the role of remote forcing of adjacent continental monsoons on the equatorial Pacific climate has been assessed. However, to fulfill our research goals, the coupled intermediate model alone is insufficient. Therefore, we have made substantial efforts in developing numerical model tools.

The first effort is to establish the hybrid coupled AGCM-ocean model. This hybrid coupled model consists of he ECHAM (European Center-Hamburg Atmospheric Model) and our intermediate ocean model. It is a fully coupled (dynamic and thermodynamic) model without flux correction. Long term- integration has shown that its simulation of the global monsoon systems has been significant improved. Its simulation of ENSO has also been recently improved significantly.

The second effort is to develop a regional climate model. This model has the ability to make a high-resolution (up to 5 km) simulation of the regional climate. It has been used to successfully simulate 1998 summer extremely flooding season climate anomalies in the East Asia. It has been also used to investigate the impacts of the deforestation in Indo-China on the local and remote summer rainfall.

These two newly developed models lay a solid foundation for fulfilling the goals of our PACS research projects as can be seen from the subsequent description of our accomplishments below.

Investigation of the impacts of the radiation-stratocumulus cloud interaction

The regional climate model has been shown to be able to realistically simulate the eastern Pacific cold season (Aug.-Oct.) climate, especially the boundary layer clouds.

This model has been recently used to study the role of the radiative forcing of the eastern Pacific stratocumulus cloud on the cold tongue-ITCZ system. It is shown that the radiative forcing associated with the cold tongue stratocumulus clouds generate a shallow local meridional circulation between the ITCZ and equatorial cold tongue, which could enhance ITCZ precipitation by about 10-20% and shift ITCZ northward to the west of 95W by about five degrees of latitude.

Study of the Great Plan summer rainfall variability

This study has started and current activity includes both a diagnostic and modeling component. The diagnostic work will be summarized in the first part of 2003 and we expect to submit for publication by the end of 2003.

Interdecadal and Biennial Variability of ENSO: Impacts of the Mean States and Tropical-Extratropical Interaction

PI: Bin Wang, Soon-Il An

Purpose of the Project

The proposed research is aimed at addressing the following scientific questions: 1) Why does ENSO have considerable variability in its amplitude, frequency, coupled structure, and evolution on interdecadal time scales? 2) What roles do atmospheric transient eddies play in the tropical-extratropical interaction and the interdecadal variation of ENSO? 3) Why does ENSO have a significant quasi-biennial component? The unified theme of the proposed research is to understand how the mean state variations and tropical-extratropical interactions impact ENSO behavior.

Progress During FY 2003

In the past year, we have completed two studies on the variability of the ENSO-monsoon system.

Impacts of atmosphere-warm ocean interaction on Monsoon variability

A common wisdom regards SST anomalies in the Indian and western Pacific Oceans as a cause for monsoon variability. Our analysis suggests that the SST anomalies in these warm ocean regions are, to a large extent, a result of anomalous monsoon. We demonstrated that it is the atmosphere-warm ocean interaction that may significantly modify the impacts of remote El Niño forcing. The local monsoon-warm ocean interaction should be regarded as one of the essential physical factors that determine the monsoon variability.

The atmosphere-ocean conditions in the two regions of anticyclones are similar, namely, a zonal SST dipole with cold water to the east and warm water to the west of the anticyclone center. These conditions result from a *positive feedback between the anomalous anticyclone and SST dipole,* which intensifies the coupled mode in SIO during El Niño growth and maintains the coupled mode in the WNP during its decay. The outcome of this interaction depends crucially on the climatological surface winds. The interaction in the two regions share common wind-evaporation/ entrainment and cloud/radiation feedback processes but differ in the roles of oceanic dynamics (vertical and horizontal advection and thermocline adjustment by oceanic waves).

Interdecadal changes of the ENSO and East Asian summer monsoon (EASM) relationship

Using station rainfall data and the NCEP-NCAR reanalysis, we found that in the late 1970s, remarkable changes occurred in summer rainfall anomaly in northern China and Japan. From pre- to post-1977 period, the summer rainfall anomaly in eastern North China during decaying phases of El Niño changed from above to below normal, whereas that in central Japan changed from negative to normal.

The change in ENSO-related East Asian summer circulation anomaly is attributed to changes in the location and intensity of anomalous convection over the western North Pacific (WNP) and India. After the late 1970s, the WNP convection anomaly is enhanced and shifted to higher latitudes due to increased summer mean SST in the Philippine Sea. This induces an eastward shift of an anomalous low pressure from East Asia to the North Pacific along 30°-45° N during decaying phases of El Niño. Thus, anomalous winds over eastern North China and Korea switch from south-easterly to northeasterly. Before the late 1970s, an anomalous barotropic anticyclone develops over East Asia and anomalous southerlies prevail over eastern North China during decaying phases of El Niño. This may relate to anomalous Indian convection through a zonal wave pattern along 30°-50° N. After the late 1970s, anomalous Indian convection weakens due to a decreased influence of ENSO in relation to ENSO frequency change, which reduces the impact of the Indian convection on the EASM.

Profiling Float Delayed-Mode Salinity Calibration and Ocean Climate Research

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

Purpose of the Project

The main goal of the Argo program is to deploy and maintian a global array of 3,000 profiling CTD floats which should revolutionalize observational oceanography. The purpose of this proposal is to allow JIMAR and PMEL researchers to work together to refine a delayed-mode salinity calibration system that compares float salinity measurements to a climatology and provides conductivity adjustments with error bars, and apply this sytem to U.S. Argo floats. In addition, these same researchers use these adjusted float data to conduct ocean climate research. Next year the project will also be working to contribute floats to the Argo system.

Progress during FY 2003

The delayed-mode salinity calibration system for Argo floats (see <u>http://floats.pmel.noaa.gov/argo/index.jsp</u>) has been refined this year. Mapping lengthscales and calibration characteristics have been set, and the climatological calibration database has been updated to the World Ocean Database 2001. We have also assisted international Argo colleagues by sharing our calibration system and helping them apply it to their float data. We participated in the Argo data format panel and the preparation of Argo Data Management User Manual Version 2. We worked with Argo Director to



Float profile locations and nearby historical data. The density and measurement scatter of historical data around the float profile locations determine the errors of the climatological salinity estimates, which in turn determine the errors of the calibration.

attempt to define the entire process of delayed-mode quality control for Argo salinity data. We also published a manuscript on the formation and fate of South Pacific Eastern Subtropical Mode Water using the Argo data.

Methods for Assessing the Impact the Impact of Climate Variability and Climate Change on Human Health

P.I.: Michael P. Hamnett

Purpose of the Project

Building upon the previous Pacific region-wide project, the purpose of this project is to develop a multifaceted case study of the impact of climate variability and change in the Cook Islands, Federated States of Micronesia and Fiji. The project has been a collaborative effort of the University of Hawaii, the East-West Center, the Fiji School of Medicine, the Fiji Government and the Cook Islands Government. The project will attempt to clarify the relationships between climate variability and disease in these three countries, employing data at the sub-national/island level, and develop research protocols that can be used in other Pacific locations as well other insular parts of the world.

Progress During FY 2003

After funding delays of over nine months, fieldwork supported by East-West Center was completed for Fiji and Cook Islands. Data for Cook Islands proved to be inadequate for analysis and the scope of the project was narrowed to Cook Islands. Students and staff at Fiji School of Medicine compiled health data from fifteen health centers on the monthly incidence of dengue, diarrheal disease, cholera, leptospirosis, acute respiratory infections, influenza, and ciguatera fish poisoning. Fiji Meteorological Service compiled monthly rainfall, mean maximum temperature, and mean minimum temperature data for sixteen climate stations. Additional data were compiled on tropical cyclones.

Statistical analysis is currently being completed and several relationships appear to be statistically significant between the climate variables and the monthly incidence of dengue fever, influenza and fish poisoning. The results are

now being written up for presentations for a national workshop for health and met service officials to be held September 17 and 18 in Suva, Fiji.

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 has been excellent. NWS supports students research 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.

Basic Weather Studies

P.I.: Thomas Schroeder

Purpose of the Project

Funds from the NWS are used primarily to support graduate students; a small portion is used to maintain computing infrastructure within the UH Department of Meteorology. During this fiscal year two students completed MS theses and three others have been supported. The research topics range from numerical simulation of local weather to tropical cyclone intensification.

Progress During FY 2003

Andrew Levine has completed his analysis of typhoon intensity changes upon recurvature. The goal of the investigation was to evaluate the utility of potential vorticity (PV) as a forecast tool for intensity change. The effort was motivated by positive results reported for Atlantic systems. Deformation of the one potential vorticity unit (PVU) around a typhoon on the 330K isentropic surface appeared useful guidance for weakening



Birds gliding on the tropical storm force winds of Jimena on the morning of the September 1, 2003. Photo by Chris Chambers.

recurving storms. In five cases of a trough of high PV at the 345K surface within 10° radial distance PV fields were too subtle to be useful in isolation from other variables. Mean vertical shear of the horizontal wind and Maximum Potential Intensity (MPI) were included. Mean vertical shear (850-200 hPa) over intensifying typhoons was less than that over weakening storms. Shear increased with approach of the PV anomaly to the storm center. Weakening coincided with the anomaly approaching within 5° of the storm center. Storms near their MPI and over constant temperature waters weakened. Forecasting guidelines based on the limited sample (14 storms) were developed.

Ryan Lyman completed his analysis of the October 29, 2000 extreme rainstorm over East Maui. This was the first use of archival quality WSR-88D radar data in a Hawaiian case. Radar analysis indicated that the "storm" began as a series of short-lived cells forming along the east slope of Haleakala. A long-lived cell developed which proceeded to produce most of the 700 mm of rain over about a four-hour period. The cell developed as trough aloft drifted over the island and produced subtle changes in the steering winds. These steering flows coupled with the topography appear to have "anchored" the system.

Chris Chambers has applied the MM5 model to the island of Kauai. This is the first attempt at mesoscale modeling of that particular island which is famous for the copious rainfalls at the summit of Mt. Waialeale. Chris is conducting a series of experiments to evaluate the orographic influence of Kauai under a variety of synoptic conditions.

Brooke Bingaman is working closely with the NWS Honolulu Forecast Office to develop climatology of the trade wind inversion over the islands. The trade inversion and its variability (including its occasional absences) is a fundamental element of the basic weather variability in the State as well as a fundamental controlling factor in the tropical general circulation.

The International Pacific Desk

P.I.: Thomas Schroeder

Purpose of the Project

The JIMAR/NWS International Pacific Desk, established to provide training for meteorologists from Pacific Basin nations (contained within World Meteorological Organization (WMO) Regional Association 5) is completing its third year of operations. 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). They are exposed to modern analysis and forecast techniques as well as the research environment of JIMAR and UH. They work closely with Robert Larson (retired NWS senior forecaster and JIMAR trainer). Upon the conclusion of their time in Honolulu they 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. This program has been well received and the trainees eager to participate.



Robert Larson, JIMAR Meteorologist/Pacific International Desk Trainer works with Trainee Neniasi Havea from Tonga. The Pacific International Desk provides training for meteorologists from the South Pacific Islands (World Meteorological Organization Regional Association 5).

Pacific GPS Facility: GPS Meteorology in Hawaii

PI: James Foster, Steven Businger, and Michael Bevis

Purpose of the Project

Near Real Time GPS Meteorology Network

The PGF Near-Real-Time GPS meteorology network SkyNet¹ ran continuously through 2002-2003. Hourly data from sites STEP at the Mauna Loa Atmospheric Observatory, MLPM at ~2000 m on Mauna Loa's south east flank and HILO at the Hilo International Airport were added to the batch processing, bringing the number of Hawaiian GPS sites to 11. HILO and MLPM are equipped with meteorological units while surface temperature and pressure for



Figure 1. Histograms of precipitable water for MKEA, PGF2, and PGF4 with lognormal PDF curves superimposed. The parameters t, M and s for each PDF curve are: -1, 2.19, 0.581; 0, 20.45, 0.301; 0, 28.14, 0.256 respectively.

STEP are retrieved from the MLO real time meteorology data stream. The receivers at STEP and MLPM belong to the USGS/Stanford University, and therefore, are not under our control, however the data are made available to us through our collaborative data sharing agreement with these institutions.

Ongoing efforts should bring the established sites HNCL near downtown Honolulu and LHUE at the National Weather Service office in Lihue, Kauai, into SkyNet. We are simultaneously preparing to move sites (where it is feasible) to half-hourly session downloads in order to reduce the latency in the near-real-time products.

Processing for 2002 was successful for ~94% of hourly batches. Failed batches were primarily due to network outages, resulting in the absence of data from fiducial IGS sites and the precise orbit solutions from SOPAC. Data stream failures at individual sites have been largely power related and we are in the process of "hardening" the power supplies at these sites.

Current Research Efforts

There are three research initiatives currently underway. First, we are investigating the possibility of developing an index for to predict the rainfall associated with tradewind showers, using on GPS precipitable water estimates in tandem with balloon and aircraft soundings. Prediction of the intensity of localized upslope showers during tradewind conditions remains a forecasting

¹ SkyNet: http://www.soest.hawaii.edu/pgf/public/SkyNet/NRT_Summary.html

challenge in Hawaii. It is anticipated that, under tradewind conditions, the likelihood of these showers producing significant precipitation is related to the thickness of the moist layer. Using balloon and aircraft (ACARS) soundings to confirm the existence of a well defined moist layer and GPS to track short term variations in PW we hope to be able to define an index that will aid local forecasters in predicting rainfall.

Secondly, we are testing the relationship between precipitable water and heavy rainfall found for the Ka'u Storm with other deep convective storm events in order to define a more general empirical tool for nowcasting of flash flood events in Hawaii.

Third, we are extending the investigation of the lognormal distribution of precipitable water found in Hawaii to sites around the world. This may have direct implications for the parameterization of delay in GPS processing which is currently handled with the assumption that (wet) delay is normally distributed. The results may also have application to climate modeling, by helping specify how moisture is parameterized in the models.

Compilation, Digitization, and Use of Hawaii State Rainfall Records

P.I.: Pao-Shin Chu

Purpose of the Project

To compile and digitize historical, monthly rainfall records from the Hawaii State Climate Office (HSCO). The state data come from numerous volunteer observers such as sugar plantations, ranchers, pineapple companies, individuals, and others. The state data are unrelated to the NOAA/NCDC 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 2003

We have completed the state gages with more than 10 years of records for the island of Oahu. In all, 429 rain gages were compiled and digitized. Also included were the state key number, station name, observer name, latitude, longitude, and elevation. It is noteworthy that there are 103 gages with more than 50 years of records, a potential source for climate change studies (Figure 1). Only gages with more than 10 years are used. It is clear that the state gages have a very good coverage in central Oahu, north shores from Haleiwa, Kahuku to Kailua, Ewa, and Honolulu, where the federal (i.e., NCDC) coverage is sparse. Combining the state and federal networks would yield an optimal spatial coverage to resolve the microclimate features in rainfall variations across the island. In the meantime, all state gages on the island of Hawaii have been inventoried.



Figure 1. The location of rain gages from the HSCO (red) and federal (blue) networks in Oahu.

FISHERIES OCEANOGRAPHY

Fisheries oceanography has become the largest component of JIMAR. The program has three components: 1) Collaborative research with the Honolulu Laboratory 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 Honolulu Laboratory

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

P.I.: Thomas Schroeder [Jeffrey Polovina]

Purpose of the Project

This is a new proposal that provides UH researchers access to satellite oceanographic data assembled by NOAA to use in their physical and biological oceanographic research. This project builds on previous collaborations between researchers at the UH and at the Honolulu Laboratory to validate and interpret satellite oceanographic data. Data sets including sea surface temperature, winds, altimetry, and ocean color from national data bases and made available though the NOAA CoastWatch Program. Collaborations will occur between UH researchers with expertise in interpretation and application of satellite oceanographic data and scientists interested in using these data in their marine science research. Products will be used in presentations and publications on fisheries and protected species.

Progress During FY 2003

Processed and served on our web site satellite oceanography data and imagery including altimetry, ocean color, sea surface temperature, and surface wind products for the entire North Pacific. Provided specialized analyses of these data to a wide range of users. Used the data in two publications to describe the ocean habitat of loggerhead and olive ridley sea turtles.

Western Pacific Fisheries Information Network (WPacFIN)

P.I.: Thomas Schroeder [David Hamm]

Purpose of the Project

The Western Pacific Fisheries Information Network (WPacFIN) project is designed to improve availability of high quality fisheries data needed for research and fisheries management by improving data processing and data management capabilities of the State of Hawaii Division of Aquatic Resources (HDAR) and the U.S. affiliated island fishery agencies in American Samoa, Guam, and the Northern Mariana Islands by providing computer hardware and technical software support. It also provides technical support to NMFS Honolulu Laboratory and JIMAR researchers for fisheries monitoring, data management, and analysis and reporting. Windows-based Visual FoxPro database management systems are being developed and implemented to provide fisheries statistics to various research projects within JIMAR and NMFS and other local,



David Hamm conducted WPacFIN Document Imaging and Archival System (DIAS) training for the PIAO, WPRFMC(Council) and the Island Agency.

federal, and international agencies. Web pages and web-based applications and support are also being developed and maintained to increase data availability.

Progress During FY 2003

Progress and accomplishments were made in all supported island fisheries agencies in the areas of upgrading computer hardware and OTS software and in developing and implementing numerous upgrades to project-developed database applications software for processing and analyzing fisheries data in support of fisheries management and research. One of the most significant accomplishments made in Hawaii during FY2003 was the full implementation of the new Visual FoxPro data system for processing fisheries data submitted on the new suite of fisherman reporting forms implemented by HDAR in October 2002. Additionally in Hawaii, a new Document Imaging and Archival System (DIAS) was implemented which greatly enhances efficiency of document handling; forms receipt tracking, database integration, and document retrieval. A similar DIAS system was also implemented at the Guam Bureau of Statistics and Plans (formerly Guam Department of Commerce) and other enhancements made to their tuna transshipment

processing system. A new "trip ticket" commercial fisheries processing system was completed and implemented both in Guam and the CNMI fisheries agencies and a major new inshore creel survey processing system was implemented in Guam. In Samoa additional modifications were made to the federal longline logbook system and other commercial landings monitoring systems to improve data quality, report generation capabilities, and cross-system data integration algorithms. At the Honolulu Laboratory, the WPacFIN website (<u>http://wpacfin.nmfs.hawaii.edu</u>) underwent a major redesign and new automated updating procedures were used throughout the year to update and add to the many hundreds of tables and graphs contained in the site. Project staff were also instrumental in filling numerous ad-hoc data requests from many researchers and fisheries management organizations, and in compiling fisheries statistics used in the NMFS HQ publication "Fisheries of the United States" in the WPacFIN "Fishery Statistics of the Western Pacific" publication, and in fisheries status reports to the Council for the bottomfish and pelagics Fishery Management Plans.

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 National Marine Fisheries Service Honolulu Laboratory, 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 Schroeder [Christofer Boggs]

Purpose of the Project

This project involves NMFS Pacific Islands Fisheries scientists, fishing industry and fishery management council managers and academic scientists working together and conducting cooperative research to improve scientific information, encourage collaboration, improve communications, use fishermen's expertise and vessels and directly involve the fishing industry. The program is intended to answer scientific questions of immediate importance to industry and mangers and to provide critical information for fishermen to better manage their businesses. Specifically, this project will fund workshops to develop integrated, comprehensive, prioritized proposals to be considered for funding as cooperative research projects for U.S. affiliated islands in the western Pacific, e.g., American Samoa, Guam and Northern Mariana Islands.

Progress During FY 2003

At no cost to the project, meetings with fishermen to solicit research ideas were held by NMFS and the Fishery Council in American Samoa (June 2002) and in Guam (February 2003).

Research Support

P.I.: Thomas Schroeder [Susan Kamei]

Purpose of the Project

This project provides research support for fishery data monitoring and research operations as well as building and maintenance. This project supports staffing costs for a JIMAR Fisheries Specialist who is responsible for providing timely, high quality data to JIMAR researchers. The specialist collects logbooks from Hawaii longline vessels, verifies the data and monitors the Honolulu seafood market to obtain size-composition and other scientific information from commercial fishery landings. Funding also supports staffing costs for the building maintenance assistant who provides support to all JIMAR principal investigators in support of research operations.

Progress During FY 2003

The JIMAR Fisheries Specialist continues to provide support to fishery monitoring activities by providing timely, high quality data to JIMAR and NMFS 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 three-year pilot program the use of an electronic longline logbook was initiated to provide a low effort alternative to the paper logs. The JIMAR Fisheries Specialist is pivotal in the application of this alternate reporting instrument. New databases for use in this new alternate reporting system have been made and are now in use. 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. The building maintenance assistant continues to provide essential program support to PI's to enable them to carry out their research activities by maintaining the facility and equipment used in their daily work.

Economics of Fisheries Initiative

P.I.: Thomas Schroeder [Minling Pan]

Purpose of the Project

The main goal of this program is to provide estimates of the value of commercial and recreational fisheries. These estimates would be used in the context of the Western Pacific Regional Fishery Management Council's Fishery Management Plans 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.

Progress During FY 2003

The main progress of the economics studies in FY03 include:

- 1. Collaborated with PIRO's observer program for a new approach toward continuous economic data collection. PIRO has subsequently committed staff (observers) to collect economic data on the observed trips and such an agreement will be written in the next contract of the observer program;
- 2. Evaluated approaches to update the input-output model of Hawaii's commercial and recreational fisheries that was first developed in 1998. A research firm (SMS) has expressed interest in taking on the task of updating the 1992 Input-Output Model appended with four fisheries sectors with the latest available State Input-Output Table (1997 Table). Currently, a draft contract between JIMAR and SMS is under review;
- 3. Conducted a field study on the tournament participants in the Hawaii tournament evaluation study. Also, field interviews have been conducted to collect cost-earning data from a small sample of the Hawaii longline fishermen; and
- 4. Acquired additional funding to support on-going projects and expand new projects to pertain economics studies on Hawaii fisheries.

Sea Turtle Valuation

P.I.: Thomas Schroeder [Stewart Allen]

Purpose of the Project

The project is designed to develop the framework and research methodology for a potential future study or set of studies estimating the economic values associated with threatened and endangered sea turtles in the western Pacific. Many regulatory actions have been instituted to reduce bycatch of these sea turtles without a clear understanding of their non-market values and the policy trade-offs associated with alternative recovery techniques.

Progress During FY 2003

A contractor, Dr. John Duffield of the University of Montana, was hired to conduct the project. He completed a literature review of economic valuation of endangered species and presented his findings at a well-attended seminar on April 1, 2003. During that week, he also met with PIFSC staff, Council staff, and others. The main product of the week, co-authored with Stewart Allen, was a brief sketch of five possible studies spanning interests in Hawaii, the mainland U.S., and the Pacific Rim.

Two of these studies were identified as worthy of further exploration. The first would be a policy and valuation analysis for two of the key pelagic turtle species: leatherbacks and loggerheads. The combined study would have three main components: samples of some Pacific Rim cultures that live near or utilize leatherback nesting beach habitat; samples of developed nations that are both consumers and providers of turtle protection (Australia, U.S. and Japan);

and samples of commercial fishermen in the Western Pacific. The economic feasibility of turtle protection efforts both for nesting beaches and in coastal and high seas fisheries would be examined. The second would be an *ex post* analysis evaluating the significant change that has been instituted for the Hawaii-based longline swordfish fishery. The foregone revenue from this fishery provides some evidence of protected species values as revealed by that public decision. This project could involve a survey of Hawaii residents as well as U.S. residents to estimate passive use values associated with pelagic sea turtles. Sampling different strata within Hawaii would likely provide some interesting findings on attitudes toward turtles, endangered species in general, and commercial fishing.

Lobster Research Program

P.I.: Thomas Schroeder [Gerard DiNardo]

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.

Progress During FY 2003

A three-year NWHI lobster research plan was submitted and approved by the Western Pacific Regional Fisheries Management Council (WPRFMC). Numerous presentations on the status of lobster research were also presented to the WPRFMC. Spiny lobster tagging experiments were conducted at Necker Island from September 8 to October 7, 2002 and approximately 14,000 lobsters were tagged and released. The 2003 NWHI lobster resource survey was conducted from June 11 to June 30, 2003 and data from the survey are being edited and key-punched.

Don't Duck Metadata

P.I.: Thomas Schroeder [Michael Parke]

Purpose of the Project

Create metadata records for Pacific Islands Science Center geospatial data files.

Progress During FY 2002

Finally was able to hire a Geography Department graduate student to work 10 hours per week. Made progress on creating metadata and metadata index for all bathymetry datasets of Hawaii and NWHI. Advertised for additional student hire, but expect few applicants given the scope of work and level of pay offered.

Pelagic Fisheries EFH Research

P.I.: Thomas Schroeder [Michael Parke]

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 and environmental conditions using spatial overlays. Store the new data created by this analysis as part of the longline logbook data archive in the HL Oracle database. This analysis can easily be extended to include endangered species interactions.

Progress During FY 2002

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



Scientist and crew aboard the NOAA vessel Oscar Elton Sette prepare to release spiny (Panulirus marginatus) and slipper (Scyllarides squammosus) lobsters captured during the 2003 NWHI lobster resource survey.Photo courtesy Michele Grace.

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 Program

P. I.: Thomas Schroeder [George Antonelis]

Purpose of the Project

The 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.

Progress During FY 2003



Weaned monk seal resting on the beach at Lisianski Island. Photo by Alan Kam.

Recent analysis of the Hawaiian monk seal demographic data indicates that the monk seal population in the NWHI is not doing well. Highlights include:



Figure 1. Historical trend in beach counts (non-pups) of Hawaiian monk seals at the six main reproductive subpopulations.

An overall decline in the monk seal beach count abundance index has occurred recently (Figure 1), especially at French Frigate Shoals and Lisianski Island, while previously increasing seal numbers have stabilized at Pearl and Hermes Reef and Midway and Kure Atolls. Until recently, the decline at French Frigate Shoals has been balanced by growth in the "recovering" subpopulations in the western end of the NWHI, but growth at these sites seems to have leveled off. Counts have not changed significantly at Pearl and Hermes Reef and Kure Atoll since about 1996 and at Midway Atoll since about 1999. It is difficult to determine if these changes have been due to sample variability or to an actual change in subpopulation trajectory, but it's starting to look more like the latter.

In some cases changes in site-specific abundance have been preceded by, or simultaneous with, reduced juvenile survival. In 2001, there was low yearling survival at all sites except Pearl and Hermes. In 2002, yearling re-sights were very low at Lisianski Island, Kure Atoll, and Pearl and Hermes Reef, but did increase slightly at Laysan Island and Midway Atoll. Preliminary population information indicates that re-sights of yearlings may be similar in 2003. Additionally, relatively low age-specific reproductive rates have been observed at two sites (French Frigate Shoals, Lisianski Island).

The above trends are consistent with either episodic or chronic prey limitation and may be associated with decreased oceanic productivity over the last few years. While additional monitoring and more complete demographic analyses will undoubtedly help elucidate the relative importance and mechanisms involved in various factors limiting growth, the evidence presented at the recent Hawaiian Monk Seal Recovery Team meeting (December 4-6, 2002) was sufficient to cause some alarm.

Swordfish Research

P.I.: Thomas Schroeder [Stewart Allen]

Purpose of the Project

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

Progress During FY 2003

Developed a metadata repository being used to document database fields and implemented a user-friendly web interface for access. Database was generalized to permit collection of additional datasets. Database issues management system was created to permit electronic reporting of data problems and provide feedback on issue resolution.

Redesigned the longline observer Access database and developed in Oracle to improve data quality and system reliability. Developed longline catch and reports on effort for domestic and international fishery management.

Marine Turtle Research Program

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

Purpose of the Project

Recent turtle research has focused on the ecology and biology of turtles and trends in nesting; the satellite tracking of pelagic turtles and fishery interactions; and the etiology and epidemiology of fibropapillomatosis disease, modes of transmission, the role of viruses and toxic blue-green algae.



Fibropapilloma disease affliction involves emaciation, anemia, bacterial blood infections, immunosuppression, and cardio-vascular parasite infection. Photo by Ursula Keuper-Bennett.

Progress During FY 2003

Between July 2002 and May 2003, a total of fifteen scientists from Pacific nations, Australia, Taiwan, the U.S. mainland, and the islands of Hawaii and Maui spent between two and fourteen days in six separate workshops at the Honolulu Laboratory for collaboration and training. A planning session was conducted on toxin algae research in relation to health issues of Hawaiian and Australian sea turtles. 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 on the islands of Oahu, Hawaii, Maui, Kauai, Molokai, and Lanai. A collaborative study was conducted on the pelagic ecology of sea turtles in the North Pacific that interact with longline fisheries. Also, collaborative research was conducted in Japan involving pelagic sea turtle tracking to gain insight of the ecology of Pacific loggerheads relevant to longline bycatch

and mitigation. Similarly, visits to the islands of Hawaii and Maui were made to deploy a satellite tag on juvenile green turtles for release back into the wild. A remote viewing digital imaging system was installed to experimentally monitor and assess basking and nesting turtles at East Island, French Frigate Shoals.

Names of Students Graduating with MS or PhD Degrees during FY 2003

Yvette Anderson. 2002. The ecological relationship between the tumor-promoting dinoflagellate, *Prorocentrum* spp., and fibropapillomatosis in green turtles (*Chelonia mydas*) in Hawaii and Florida. Masters of Science Thesis, University of Florida, 210 p.

Methods Aimed to Reduce Sea Turtle-Longline Interactions: Behavioral Tests of Modified Bait and Fishing Gear

P.I.: Thomas Schroeder [Yonat Swimmer]

Purpose of the Project

The ultimate goal of these experiments is to develop chemical bait treatments that reduce or eliminate sea turtle interactions with longline gear without negatively impacting the ability to capture target fish species. To accomplish this goal, a series of behavioral experiments will be designed to (a) assess the olfactory capabilities of sea turtles and (b) to determine odors that are repellant to sea turtles but not to target fish species.

Progress During FY 2003

Behaviors of both green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles were quantified in the presence and absence of various chemicals diffused into their aquatic environ-



Bait modification experiments showed that loggerhead and green turtles preferred untreated bait over blue-dyed bait. Photo courtesy Michele Grace.

ment as well as saturated into food items. Experiments using "artificial baits" that disguise visual differences between edible items were conducted in order to determine if turtles use olfactory or gustatory cues to bite "food." This test was not intended to discriminate between taste and smell. Therefore, further tests of "hidden baits" were conducted to investigate turtles' reliance on smell alone. In order to quantify turtles' response to hidden food items, a turtle's position in relation to diffused food chemicals was scored using video images.

Experiments were conducted on 10 green turtles at the NMFS Kewalo Research Facility in Honolulu, Hawaii and on 47 loggerhead turtles at the NMFS Sea Turtle Facility in Galveston, Texas. For both turtle groups, the majority of turtles ignored the "artificial baits" presented. Of the turtles that ate, however, artificial baits with known foods were selected more often than items lacking food, suggesting that olfactory or gustatory cues appear to play at least some role in turtles' decision to swallow bait. Results from hidden bait experiments from both turtle groups suggest that turtles are not attracted to a food source from an olfactory cue alone. Before a definitive statement can be made, however, further work must be conducted that controls for various factors, such as direction of plume, water flow, and turtles' gular pumping.

Protected Resources Environmental Compliance Initiative

P.I.: Thomas Schroeder [Margaret Akamine]

Purpose of the Project

Develop and implement strategies to further recovery of federally protected species; conduct consultations under the Endangered Species Act and prepare biological opinions; revise and maintain the Marine Mammal Stranding Network to fulfill mandates under the Marine Mammal Protection Act (MMPA); and assists in analysis and strategies for management of federal fisheries so that federal mandates under the Endangered Species Act (ESA) and the MMPA are met.

Progress During FY 2003

Data analysis, tracking, and information gathering for environmental compliance consultations were completed in FY 2003. Assistance with the cooperative framework for NGOs to assist with marine mammal emergency actions in the Main Hawaiian Islands. Staff increased to better handle workload and interface with the NOAA Fisheries Pacific Islands Fisheries Science Center staff re data gathering/analysis.

Additional projects under the new cooperative agreement will include the implementation planning and activities for the sea turtle recovery plans, Hawaiian monk seal management in the Main Hawaiian Islands, review of Federal Fishery Management Plans for consistency with the ESA and MMPA, and preparation of required documentation. Design and implementation of the program to meet growing needs in other Pacific Island areas under the jurisdiction of the U.S. The completion of an MOU between the Protected Resources Division and the U.S. Coast Guard District 14 for support and exchange of information regarding protected marine species.

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 [Michael Laurs]

Purpose of the Project

The project's purpose is to describe the characteristic modes of variability in the North Pacific Ocean over interannual to decadal time scales, from analysis of historical databases and numerical ocean model output. This will aid in our understanding of environmental variability in time and space, and improve our ability to manage economically important marine resources. It is part of the US GLOBEC Northeast Pacific Program, whose goal is to understand the effects of climate variability on marine animals, and to incorporate this understanding into prognostic models.

Progress During FY 2003

Important foci of this project during this past year have been: 1) continued analysis of ocean climate variability in the upper 500 m, compared to atmospheric variability patterns; 2) applying statistical methods to identify the timing and

magnitude of abrupt changes (climate shifts) in environmental time series on interannual century time scales; 3) describing global atmospheric teleconnection patterns of climate variability, as a mechanism for climate interactions between the tropics, north Pacific, and north Atlantic; and 4) comparing anomalies associated with El Niño/La Niña events and decade-scale climate shifts, and the mechanisms responsible for them. A priority has been the preparation of several scientific presentations and publications describing these results.

From this research, we have identified discrete times of climate shifts from historical data sets, including a recent dramatic regime shift in 1998, which have had significant ecological consequences. Our analysis has also revealed that subsurface temperatures responded to a regime shift in the 1970s several years prior to its surface manifestation, and defined three characteristic patterns of El Niño influence in the California Current, reflecting both the meridional extent and depth structure of their signals. We also have characterized patterns of global atmospheric interaction, which are thought to be responsible for linking observed climate shifts in the north Pacific to other regions, including the tropical Pacific and north Atlantic.

3) The Pelagic Fisheries Research Program (PFRP)

Pelagic Fisheries Research Program: Program Management

P.I.: John Sibert

Purpose of the Project

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

Progress During FY 2003

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 an active member of the United States Delegation to the Third Preparatory Conference for the Commission for the Conservation and Management of Highly Migratory Fish Stocks in Western and Central Pacific in Manila, November 18-22, 2002. The PFRP hosted the fifteenth meeting of the Standing Committee on Tuna and Billfish in Honolulu July 18-27, 2003. The SCTB is the most definitive source for information on fisheries for highly migratory species in the Pacific Ocean. Participants from most Pacific Island countries, Australia, Indonesia, Philippines, Viet Nam, Taiwan, China, and Korea attended. Over 100 scientific papers and technical reports were tabled. 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.

The 2002 PFRP PI meeting featured a special session on problems of attachment and implantation of electronic tags "Tying One On". This session spawned a workshop to draft guidelines for tag attachment and at-sea surgery on fish.

Funding for all projects selected in the most recent, December 2001, request for proposals is either in place or will soon be in place. The pace of funding PFRP projects within NOAA appears to have improved greatly. Funding for projects from the FY2002 appropriation was received in a timely manner. However receipt of funds from FY2003 appropriation and carryover from FY2002 was delayed because of the delays in the Congress.

The PFRP has been actively promoting graduate education in fisheries. The PRFP Program Manager assisted in development the proposal for a new Coastal and Marine Resources graduate degree program. The Authority to Plan document will soon go to the Chancellor for signature. The position of curriculum coordinator for the CMR program was advertised and should be filled by the end of the summer.

Two graduate research assistantships were awarded. Brittany Graham, a PhD candidate in the Oceanography Department, has become 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 embarking on a project to explore the potential rolls for marine protected areas in the management of highly migratory species. The graduate research assistantship program has been successful in attracting UH faculty members to the PFRP from both the Geography and Oceanography Departments.

Regulatory Impact Analysis Framework for Hawaii Pelagic Fishery Management: A Multilevel and Multiobjective Programming Model

P.I.: Samuel Pooley and Minling Pan

Purpose of the Project

The objective of this project is to enhance the multi-level multi-objective programming model for the Hawaii fisheries, developed under PFRP Project #2066/2113. This will involve making the basic model structure more tractable for regulatory analysis, and to allow more flexible time-area specification as well as updating the underlying data. The update focuses on the Hawaii longline fishery.

Project Activities and Progress During FY 2003

Modify GAMS (General Algebraic Modeling System) programs and input data files to be simpler and more easily modified with respect to area, season, target, and species. The updated programs were validated by reproducing the same results as those previously produced by the Leung project.

Develop a couple of data processors that flexibly generate the parameters for 5-8 areas that are more realistic for fisheries management. These data processors use the following three existing data sources, which were collected and processed by NMFS Honolulu Laboratory:

- Longline logbook data summarized into monthly 1-degree square areas, by target (billfish/mixed/tuna) and vessel size (small/medium/large),
- · Longline trip data generated from the original logbook data, and
- Auction Data to estimate fish price and weight for each species/season/target.

Apply the model with a new time-area specification, where Hawaiian waters are divided into five areas (Main Hawaiian Islands, North-East, North-West, North-Center that were closed during Dec 1999-Mar 2001, and South, and one year is divided into five periods (Jan-Mar, Apr-May, Jun-Jul, Aug-Sep, and Oct-Dec). This specification is to analyze the impacts of the regulatory policies during 1999-2002. However, this model was first applied to examine the model's predictability using the 1993 data because the previous study was done for Year 1993 and the most complete cost-earning data set is available for that year.

Evaluate alternative objective functions with different constraints to examine alternative economic assumptions for the Hawaii longline industry (i.e., competitive equilibrium where resource rent is dissipated vs. effort allocation by a sole fishery regulator where resource rent is maximized). The analysis of the model results is continued while the project reexamines and revises the cost parameters (e.g., fixed and operating costs, and expected wages) for the three longline fleets.

Names of Students graduating with MS or Ph.D. degrees during FY 2002

Keiichi Nemoto was awarded the Ph.D. in Agricultural and Resource Economics, December 2002.

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

P.I.: John Sibert

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 2003

Preliminary work for the analysis of the Hawaii Tuna Tagging Project data using the advection-diffusion-reaction model (ADRM) has been completed. Fishing effort data from NMFS and HDAR sources has been assembled through 2001 and aggregated at 60 and 20-mile spatial resolution. Some delays were encountered in assembling these data.

The state space Kalman filter model was developed further and applied to a wide variety of species including marine turtles, bluefin tuna, marlins, and elephant seals. The model was extended to also be applicable tracks from animals with Argos transmitters, to estimate parameters for different segments of a track, and to estimate common suite of parameters from multiple tracks. This work was greatly assisted by Mr. Anders Nielsen, a graduate student from the Department of Mathematics and Physics at The Royal Veterinary and Agricultural University in Denmark. Nielsen created an interface to go between the Kalman filter model and the R statistical package that make the model much easier to apply. This software is available for download from the PFRP web site http://soest.hawaii.edu/PFRP/ elec.tagdata/tagdata.html.

Work on the Kalman filter model was also assisted by a visit by Dr. Sibert to the CSIRO Division of Marine Research in Hobart, Australia sponsored by CSIRO to analyze bigeye and southern bluefin tuna tracks in the Coral Sea and Indian Ocean. In the process of analyzing the tracking data from the Coral Sea, it became clear that there are pathological autocorrelated errors in the data from some archival tags. A considerable amount of effort was invested in exploring and correcting these errors. Preliminary results indicate the bigeye behavior in the Coral Sea who the same high degree of residency as observed in Hawaii.

Dr. Shiham Adam has completed work on the neural network parameterization of the ADRM and a manuscript is in preparation.

Integrated Modeling for Hawaiian Albatross Populations

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

Purpose of the Project

The potential impact of longline fisheries on Albatross populations has been a concern since Weimerskirch documented the detrimental effect of long-line fisheries on the population dynamics of the wandering Albatross *Diomedea exulans*. Accidental by-catch of individuals of the three North Pacific albatross species (*Phoebastria albatrus*, *P. immutabilis* and *P. nigripes*) has also raised concerns on the impact of by-catch at the population level in these three species. In particular, Cousins and Cooper reviewed the available knowledge on population biology of the Black-footed Albatross, to determine if by-catch by longline fisheries was detrimental to the species. Similar concerns exist for Laysan Albatross *P. immutabilis*.

The purpose of the present project is to develop integrated population modeling for Black-footed (*Phoebastria nigripes*) and Laysan (*Phoebastria immutabilis*) albatross populations to assess whether past and present levels of by-catch are likely to affect significantly the populations of these species. The first step of the project will review the information existing on demographic parameters, and proceed with further analyses whenever needed. In the second phase, we will develop a Leslie matrix model that will be used as the core of an integrated model using the Kalman filter and combining likelihoods for the various pieces of information available. Specific questions concerning the impact of by-catch, the potential for compensation by accelerated recruitment, the additional impact of accidental deaths in terms of pair re-formation after widowing, etc. will be the examined by implementing the corresponding assumptions in the model, and by testing them.

Progress During FY 2003

The present report reviews the activity under this contract up to the beginning of April 2003. Since the subcontract with CNRS has not yet been signed, the work to date has been quite preliminary and has consisted of three main lines of activities (1) Contacts for carrying out the review of the existing information on demographic parameters, and to make decisions on further analyses whenever needed; (2) Of Sophie Véran and Vivian Hénaux (thesis students) in a workshop Bibliographic research and development of a Leslie matrix model, that will be used as the core of an integrated model; and (3) Preliminary contacts with people having responsibility for the various sources of data.

These three topics are briefly reviewed below.

Estimation of demographic parameters

• A close collaboration has been established with J.D.Nichols (Patuxent Environmental Research Center, USGS) who is presently doing survival analyses based on this material. This part has been delayed due to the data handling difficulties (double banding that had to be sorted out in the data base)

- Establish a comparative database on survival among albatrosses. Albatrosses are characterized by extreme natural longevity, which means a high adult survival. Adult survival among albatrosses present a variation from 0.857 for *Thalassarche chlororhynchos* to 0.973 for *Phoebastria palpebrata*. Black-Footed and Laysan albatrosses are located in the mean range of an adult survival estimated to around 0.93. This high survival is correlated with a low fecundity (single egg clutch and intermittent breeding). This strategy strongly increases the impact of anthropogenic perturbation. The literature has been reviewed and the estimates gathered. Comparative analyses taking into account allometric effects and phymlogenetic constraints will be done in the near future.
- Training: participation on capture-recapture analysis (advanced level).
- A Leslie matrix model
- Most bird species, and albatrosses are no exception, show seasonal reproduction, and a strong variation of demographic characteristics with age. The Leslie matrix model is then a natural tool to describe the population dynamics of the species. A matrix equation gives the vector of numbers at time t+1 x(t+1) as a matrix transform M x(t), where M depends on the demographic parameters. Up to now we built a specific model to examine the cost of pair formation after widowing and Allee effect (inverse density- dependence induced by shortage of partner availability at low densities) in Albatross populations, and examined in a preliminary way the effect of demographic stochasticity. An example of trajectories from the existing model incorporating demographic stochasticity is given below.
- Training: participation of SV et VH in a doctoral level course on population models (15 hours, matrix model formulation; estimation of eigen values and eigenvectors; perturbation analysis of population growth rate and notion of sensibility/sensitivity; age-classified matrix models and generalization to multi-stage matrix models; density dependence regulation; random environment matrix models; evolutionary stable strategy; dynamical and statistical models for exploited populations)

Contacts

At the present stage, it is too early to draw an extensive list of the pieces of information available to be combined, but a minimum will be capture-recapture information (both for survival and recruitment; possibly several distinct data sets obtained from monitoring of different colonies), census information, and by-catch information. Preliminary contacts have been established with people having responsibility for the various potential sources of data.

The main sources of data presently identified are:

- Census of the number of breeding pairs by:
- Direct counts of active nests immediately after laying has finished, on Midway Atoll since 1991, on Laysan Island since 1996 and on French Frigate Shoals since 1979. Those three main colonies represents almost 77 % of Blackfooted and Laysan albatrosses populations.
- Indirect counts in others breeding locality of the northwestern
 Hawaiian Islands: an extrapolation to total eggs from chicks
 counted between February and July and assuming a 75% of
 breeding success.
- Census to estimate the size of non-breeding population: a saturation banding and band-reading project is conducted at Tern island by the FWS. All chicks have been banding since 1979, and all unbanded adults have been banded since 1997.
- By-catch data from different longline fisheries with a monitoring program coordinated by the National Marine Fisheries Service: for groundfish longline fishery since 1990, for Hawaiian pelagic longline fishery since 1994. For other high-seas pelagic longline fisheries, there are no monitoring programs neither data of average annual take of albatrosses. As only a portion of the total fishing effort is observed, the total by catch may have to be extrapolated based on guess-timates on the portion of effort observed.



Figure 1: Projection of size of female population of Black-Footed albatross under environmental and demographic stochasticity.

· Resightings data, presently being analyzed by J.D. Nichols and his group.

Discussion

The two main difficulties up to now have been the delay in the finalization of the resighting data base and the availability of resightings analyses that have been delayed and will be available very soon, and the fact that the subcontract with CNRS in Montpellier has not yet been signed. In this preliminary step, we nevertheless solved a number of issues such as contacts and training.

Names of students graduating with MS or Ph.D. degrees during FY 2003

Two thesis students in first thesis year: Sophie Véran, and Viviane Hénaux. Thesis defense planned for fall 2005.

Tuna Trophic Ecology

P.I.: Kim Holland, HIMB

Purpose of the Project

The Tuna Trophic Ecology Project has been proceeding along three parallel paths and all three areas have made significant advances and produced fascinating data in the past year. These three areas of research are 1) Stomach

content analyses of yellowfin and bigeye tuna found in association with FADs and seamounts, 2) Investigation of the spatial and temporal dynamics of pelagic fish communities associated with anchored FADs and, 3) Tuna trophic status as determined by carbon and nitrogen stable isotope ratio analyses.

The tuna stomach contents component of this program is the longest established and has reached a level of maturity such that, although some data collection is continuing, the main tasks in the past year were data analysis and interpretation. A total of 1,338 samples (714 bigeye and 624 yellowfin) have been collected over the course of the project and so far 596 bigeye (83%) and 330 yellowfin (53%) have been analyzed.

Analysis of the stomach contents of the two target species (bigeye and yellowfin) in the various locations (associations) of interest (offshore FAD, nearshore FAD, seamount) is demonstrating that bigeye and yellowfin of similar size classes have different feeding ecologies in all the various associations. Generally stated, large yellowfin feed successfully at the offshore FADs but smaller yellowfin do not. On the other hand, small yellowfin (<75cm) feed well at the nearshore FADs (mostly on stomatopod larvae and flying gurnards). In contrast, bigeye of all sizes don't appear to feed well at any of the artificial structures (inshore and offshore FADs) that we have sampled. This seems to be due to a lack of availability of mesopelagic prey at these locations. Conversely, bigeye feed very well when associated with Cross seamount. This may be due to the fact that, in



A nearshore S-buoy FAD deployed off the leeward coast of Oahu. Photo by R. Dean Grubbs 2001

general, bigeye feed on organisms that occur deeper than those consumed by yellowfin tuna and certain seamounts seem to provide an enriched source of these mesopelagic prey. In all locations, the dietary overlap between bigeye and yellowfin of all sizes is minimal but is greatest when the animals are fond in association with Cross seamount.

Progress During FY 2003

Data collection is now focusing on obtaining stomach samples from long-line caught fish. Because longline fish are not usually caught in association with FADs or seamounts, the longline fish can be considered a 'control group' for the rest of the experiment. These samples are being collected through the collaboration of NMFS observers working on the Hawaii based longline fleet. We are also collecting small tuna from inshore FADs.

The investigation of the dynamics of FAD associated communities (mainly yellowfin and bigeye tuna) has dramatically accelerated in the past year and is already yielding extensive and fascinating results. All thirteen FADs around Oahu have been fitted with Vemco VR2 sonic data loggers and, to date, 74 FAD-associated fish have equipped with pulse-coded sonic tags that were implanted in the abdominal cavity. Ten of these fish were double tagged with

geolocating archival tags. These tags were donated by Wildlife Computers Co. in a collaborative effort to gain more insight into the behavior of the FAD-associated fish while at the same time allowing Wildlife Computers to calibrate their latest geo-locating algorithms. To date, two yellowfin tuna carrying these archival tags have been recaptured and the data successfully recovered. Thirteen additional fish have been recaptured that were carrying only acoustic tags. The data loggers on all the FADs have been recovered and interrogated at least twice and the data recovered. One transmitter has been recovered three times and redeployed. That is, it is now implanted in a fourth FAD-associated tuna!

The inter-FAD movement patterns and FAD-association dynamics results that these tagged fish are revealing are now in an active phase of analysis. At this point we are confident that database is already sufficiently large that these data will yield a significant increase in our understanding of the influence of anchored FADs on the movement and distribution of yellowfin and bigeye tuna. The sonic tagging component of the overall Tuna Trophic Ecology Program is still in an active data collection phase and in the future more animals will be released with implanted coded tags. Similarly, we will continue to retrieve and download the VR2 data loggers to expand the existing database.

In the past year, stable isotope analysis of the comparative trophic ecology of bigeye and yellowfin tuna has hit full stride. This is largely because of the arrival of a PFRP sponsored Graduate Research Assistant with expertise in stable isotope techniques who is specifically employed to advance this aspect of the overall program. During the past year, initial laboratory and field feasibility and calibration experiments were successfully completed. These experiments provided information regarding future sample size requirements, sample variability and method error. To date, 340 samples have been prepared for analysis and, of these, seventy have been analyzed for carbon and nitrogen isotopes. A range of tissue types (liver, red muscle, white muscle) was analyzed from yellowfin and bigeye tuna of varying sizes. In the early stages of this research, particular emphasis was placed on specimens caught around nearshore FADs. This strategy was adopted to compliment the FAD-associated sonic tagging experiments that were being conducted at the same time (see above). Currently, emphasis is being placed on obtaining isotope signatures from a wider size range of specimens – especially larger specimens captured by the long line fleet.

Initial results show that carbon and nitrogen isotope ratio techniques will provide valuable insights into tuna trophic ecology. Carbon and nitrogen isotope ratios obtained from bigeye and yellowfin tuna indicate that different tissue have distinct signatures. This will allow any one of these tissues to be used to characterize the trophic status of tunas. In all cases, the signatures are consistent with the hypothesized trophic status of tuna. For example, isotope values of large yellowfin and bigeye tuna caught at the Cross seamount were nearly two trophic levels higher than those obtained from juvenile tuna caught at the nearshore FADs. Another interesting early result is that one 'cohort' of fish collected from a nearshore FAD had isotope values that were elevated above those of other 'cohorts' taken from other FADs or at other times. Two possible interpretations of these data are 1) that the elevated signatures were indicative of a school of fish that had recently experienced a starvation event or, 2) that particular group of fish foraged in an area where nutrient dynamics were different. These interpretations will be tested in the coming year when feeding experiments will be conducted with captive tuna.

Describing the Vertical Habitat of Bigeye and Albacore Tunas and Post Release Survival for Marlins in the Central Pacific Longline Fisheries with PAT Tags

P.I.: Jeffrey Polovina and Michael Seki

Purpose of the Project

Project investigators plan to attach pop-up archival transmitting tags (PATs) to large pelagic fish captured by longline fishing gear in the Hawaii and American Samoa fisheries. These tags will be used to collect a time series of the animal's position, depth and water temperature. After a predetermined time interval the tags will detach and transmit these data to researchers via the ARGOS satellite. Three



Buoy crew of the NOAA Ship Ka'imiMoana recovering the Acoustic Doppler Profiler (ADP) from the BigEye Mooring.

species will have the highest priority for tagging - bigeye tunas and marlins in the Hawaii fishery, and albacore in the American Samoa fishery.

Progress During FY 2003

Project still awaiting allocation of funds from NMFS to JIMAR, thus no work has been initiated.

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

P.I.: Michael P. Seki and Jeffrey J. Polovina

Purpose of the Project

The American Samoa domestic longline fishery has recently undergone extraordinary growth, particularly in the fleet composition of large (>50 ft in length) vessels that have fueled a fivefold increase in fishing effort and landings from 1999 to 2001. Prior to the sudden expansion, most longline fishing around American Samoa were accomplished through a fleet of smaller, 30 ft., open-decked catamarans known as *alia*. To illustrate the expansion, over 50 boats actively participated in the fishery during 2001 deploying 4,690 sets (over 5 million hooks) resulting in catch rates of about 40 fish@1000 hooks⁻¹. By comparison, only 23 vessels made up the fishery in 1999, making 2,102 sets (ca. 912,742 hooks) yielding 32.38 fish@1000 hooks⁻¹. Albacore tuna (*Thunnus alalunga*) is the target species in the fishery and dominates the catch.

Oceanographically, there has been little study regarding the pelagic habitat in the American Samoa region, much less the spatial and temporal variability of the oceanographic climate. This newly funded project will (1) conduct an extensive oceanographic characterization of the pelagic habitat and fishing grounds occupied by the American Samoa longline fishery through the use of satellite oceanographic remote sensing and *in situ* shipboard surveys and (2) couple the oceanographic assessment with fishery information to develop a functional understanding of the spatial and temporal occupation and movement tendencies of large South Pacific albacore and the role of the environment on longline gear performance and catch. In the latter phase of the project, fishery information will include incorporation of albacore depth distribution and gear performance obtained from commercial longlines instrumented with time-depth-temperature recorders (TDRs) and the set level catch information from the American Samoa fishery logbook program. Products from the study will lead to a better understanding of the pelagic habitat and an improved interpretation of catch rates and patterns, thus providing information necessary to move forward on ecosystem-based fishery management policies and stock assessment efforts.

Progress During FY 2003

Initial funding for the project was received only recently in January 2003 and the study at the time of this writing is very much in its infancy. A combination satellite remote sensing and shipboard field program will highlight the efforts to characterize the oceanography of the region frequented by participants of the American Samoa longline fishery and particularly, the waters of the American Samoa EEZ. We have begun to assemble the time series of satellite products, including sea surface temperature (SST), ocean color (SeaWiFS, MODIS) and particularly, sea level height (SLH) from AVISO for the region. The first shipboard survey in waters around American Samoa is scheduled to be conducted aboard the NOAA ship *Oscar Elton Sette* in February 2004. The survey lines, which coincide to the JASON-I/TOPEX overpass orbits, will include sampling station intervals spaced to accommodate time and space scales necessary to address oceanographic mesoscale variability (e.g., 15-30 km).

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 Brill

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.

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. For example, Bigelow et al. used archival tagging data on bigeye tuna to adjust their CPUE estimates. The much larger amount of environmental data collected through time (and space) by PSATs used in our proposed research will have immediate application to CPUE estimates.

To date, 31 blue sharks (120-204 cm FL, 13 males, 18 females) captured from longlines have been tagged with PSATs in FY2001 and FY2002. Data from 16 of those deployments have been transmitted and downloaded via ARGOS satellites. These represent in aggregate 1,841 days of downloaded data for the deployments. Recovered data from deployments ranged from 1 to 247 days with a mean of 116 days ± 96 (sd). Five tagged sharks (4 females) reported their data on time (i.e. data was transmitted on their pre-programmed pop-off date, ~ 8 months) whereas the remaining 11 tags represent instances where the tag reported data before the pop-off date. In these cases, it is believed that the tag was prematurely shed, thereby triggering and initiating "fail-safe" options in the tag to report archived data. It is hypothesized that nuptial bites and/or stimulation of the biting response (possibly illicited by the electrical field produced by the tag) are likely routes of tag shedding although this idea still lacks direct experimental confirmation (see below).

In brief, although recently acquired data in March 2003 need to collated, analyzed and incorporated into the final database, the vertical data suggest that blue shark exhibit "typical" pelagic fish diving patterns with "W" movements traversing from near the surface to those below the mixed layer during the day to a baseline depth of around 400 m. Some sharks tagged in FY2002, however, made occasional forays into depths reaching 500-600 m. Nighttime movements were almost exclusively contained within the uniform surface layer. In summary, it appears that about 90% of movements were contained at depths less than 220 m at temperatures between 11° and 25°C. About 75% of all movements were found between 20° and 25°C. Although our current sample size and composition (3 males:13 females) does not have an undisputed impact, nonetheless, we observed a possible sex specific diving pattern. As identified with Kolmogorov-Smirnov tests, males and females exhibited different depth distribution patterns. Females spent 75% of time at depths less than 80 m whereas males only spent about 50% of the time within this strata. It is unclear whether this is a result of spawning behavior or represents other temporal or spatial phenomenon.

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 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.

We have had at least one blue shark die, sink, and the tag automatically jettison, float to the surface and download its data. The tagged shark showed some apparently normal vertical behaviors for the first five days, then expired and sank. We have complete confidence in the conclusion that what we're seeing is a mortality. Because of the capture by longliners of a PSAT tagged shark (after 41 days-at-liberty) we are confidence to rule attachment procedure to rule out tag shedding over this time period. Most importantly, we also now have confidence that the pressuresensitive depth release mechanisms (which prevent crushing of the tag's float), downloading procedures, and analysis of ARGOS data all work.

Because of the high prevalence of nuptial bites in female (and occasionally male) blue sharks in tagging operations conducted in March/April of 2001 and 2002, we believe this spawning behavior may be a possible route of tags getting to the surface early before their pop-off dates. Eleven of our deployments represent cases where tags reached the surface before the pop-up date. In one short-term deployment, the PSAT recorded only about one day's worth of data before transmitting. In this situation, it was evident from digital photographs that the female shark was bleeding profusely at the surface after release. We believe this may have attracted other sharks in the vicinity and that the tag was liberated as a consequence.

Further, it appears that 15 of the deployments (10 males) represent instances where the tag failed to transmit data. A logical extension is to hypothesize that mating behavior (i.e nuptial bites) or other biting behaviors may represent a possible mechanism of physical tag damage thereby causing complete tag failure. Elasmobranch predators could be attracted to electrical fields produced by PSATs. For example, Keinath & Musick suggest that a shark ate the PTT (platform terminal transmitter, similar to the one inside PSATs) affixed to a leatherback turtle in the Virgin Islands

probably because it was attracted to the electrical field emitted by the PTT. We intend to test this experimentally with captive sharks.

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. 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?

Horizontal dispersal patterns, estimated from light-based geolocation techniques for 16 blue sharks, indicated some clear patterns. For example, most sharks tagged in April 2001 and 2002 north of Hawaii, proceeded to go south for a couple of months and then turned back northwards which fits with Nakano's general distribution and migration model. Before these Kalman filtered data are further scrutinized, it is evident that researchers will need an estimate of geolocation errors provided by light-based techniques (from moving objects) before strong conclusions can be drawn. To elucidate these errors, program personnel have designed additional experiments to document the extent and possible nature of geolocation errors from moving objects as described below.

Progress During FY 2003

In addition to the blue shark data outlined above, the project personnel will also be responsible for the following PSAT data, and associated analyses and preparation of reports and articles. For these data, the project is requesting a half-salary for the senior PI for FY 2004.

Swordfish

In 2001, 8 swordfish were tagged with 4 of the tags reporting 156 days of data in-aggregate. For 2002 deployments, 17 fish were tagged with five tags reporting 371 days of data in-aggregate. Three swordfish were tagged in 2003 with pop-off dates expected in mid-May.

Oceanic white-tip sharks

Two of three white-tip sharks (all female) tagged in 2001 and 2002 reported their data representing 183 days inaggregate. Another five sharks tagged in 2002 and 2003 have not reached their pop-off dates.

Bigeye thresher sharks

In 2002, two of six tagged bigeye thresher sharks reported their data on time, which represents about 500 days worth of data. Another shark tagged in 2003 is not scheduled to reach its pop-off date until June.

Other species

Data from four silky sharks, three yellowfin tuna and three bigeye tuna are expected in August 2003. None of three tagged male shortfin make sharks reported their data.

In this relatively nascent field, it is apparent that the "Achilles heel" of this technology may be the PSAT attachment and/or anchor methodology and the magnitude of geolocation errors from light-based techniques (described below). PSATs, whether affixed to sharks, billfish or tunas, all exhibit a common phenomenon of tag shedding. For sharks, our harness system appears to work well in the short-term but certain behaviors, such as nuptial biting, may compromise this system. Still, we are experiencing some longterm deployments in seven sharks (~8% of all deployments >8 months). Indeed, it remains an open question as to why PSATs are shed by a variety of different pelagic species with different anchoring techniques. History may prove that researchers are experiencing a random distribution of deployment times and that a "magic bullet" anchoring system may never be devised that accomplishes 100% success.

Of the 87 PSATs scheduled to report to date, we have received data from 39 devices (45% overall reporting rate). In aggregate, we have 527, 279, 119, and 2582 days of observation from swordfish, marlins, tunas and sharks, respectively. There have been, however, species, year, and sex related differences in reporting rates. Of 22 male sharks tagged, only 23% of PSATs have reported. Whereas, of the 22 PSATs deployed on female sharks, 72% have reported. This difference appears to occur in blue, mako, oceanic white-tip, and bigeye thresher sharks. As mentioned for blue shark, rates of survival of sharks following release from longline gear appear excellent. We have only one

clearly-confirmed mortality. Of the eight swordfish tagged in 2001, 50% of the PSATs reported but of the 17 PSATs deployed in 2002, only 29% (5 tags) reported.

It is obvious that PSATs have provided excellent data on vertical movement patterns. For example, swordfish have been shown to exhibit diel vertical movement patterns, where they are shallow at night (< ca. 150 m) but descent to 600-800m during the day. Bigeye thresher sharks, bigeye tuna, and blue sharks show similar patterns. These behaviors, however, have prevented the on-board software in some cases from providing daily light-based geolocation estimates (i.e. the depth distributions sometimes exceed the limitations of the light sensor and deployments during the Equinox confound the algorithm). For example, of 1015 days (in aggregate) where PSATs remain attached to swordfish and bigeye thresher sharks, we received only 44 daily estimates (4%) of light-based geolocations. For blue shark, of 1841 days in aggregate for 16 sharks, we were only able to derive geolocations for 396 days (22% of the total). From these results it seems highly unlikely that PSATs will be useful for deriving light-based geolocation patterns in relation to mesoscale satellite derived oceanography for these species.

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, Richard W. Brill, and John Sibert

Purpose of the Project

Our objective is to use biochemical tools to predict the long-term survival of released Pacific blue marlin. We will work in close collaboration with the PFRP projects by Musyl and Brill to place pop-up satellite (positional and archival) tags on these fish and the Moyes, Brill and Musyl project to develop biochemical correlates of delayed mortality in blue shark. This study will also benefit from collaborative efforts with researchers in the Eastern Atlantic. We are, there-fore, uniquely situated to provide a direct correlation between biochemical measures and actual delayed mortality following release, as determined from the satellite tagging data.

Our blue shark study allowed us to develop an analytical framework for studying other species. We will 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. For example, the damage to myocardial tissue upon a heart attack causes release of proteins such as creatine phosphokinase and troponin I into the plasma. 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.

The provocative findings from our shark work have important implications for designing and analyzing blue marlin. Even in a relatively docile species like blue shark, capture induced elevations is clear in some indices of tissue damage to many individuals. Some lost almost 1/3 of their blood volume, as indicated by hematocrit. Others showed signs of heart attacks (elevated cardiac troponin I), liver and kidney damage (plasma enzymes), and most individuals showed severe muscle damage. The most provocative results were found with erythrocyte heat shock protein levels. Heat shock proteins were found to be a strong index of the health of the animal. Regrettably, many of the tagged animals shed their tags prematurely, probably due to nuptial bites. Nonetheless, we had many sharks that showed severe tissue damage but also some showed long-term survival. These studies are nearing completion and manuscripts are in preparation.

These studies on sharks have helped us as we prepare to collect and analyze marlin tissue. From blood samples, we will collect the same spectrum of ~25 parameters that assess blood loss, metabolic distress, tissue (liver, heart, muscle, kidney) damage, ion and osmotic imbalances and cellular stress responses. Additionally, we will measure from muscle biopsies the following indices of muscle damage:

• **Indicators of programmed cell death**. When cells experience significant stress, they can trigger pathways that lead to controlled cell death. Markers include DNA fragmentation and caspase activation.

• **Cellular stress response.** In many cases, warm bodied fish can experience both hyperthermia and oxidative stress, two conditions that lead to cellular damage and a compensatory heat shock response. This is assessed by measuring heat shock protein (hsp) and hsp mRNA.
Tissue breakdown. Many muscles are damaged by extreme exercise when high levels of Ca^{2+} activate enzymes that breakdown muscle protein. These proteases are probably responsible for the softening of flesh observed in some fish upon capture. Protease activation analyses focus on the enzyme calpain.

Progress During FY 2003

Shark Study

We have almost completed the analyses of the shark data. A manuscript based on these analyses in conjunction with mortality data obtained from tagging studies.

Marlin Study: Field Studies

Despite receiving funding only recently, nevertheless we (AW) were able to tag four billfish (180 lb. Blue marlin, 110 lb. Blue marlin, 200 lb. Blue marlin, 120 lb. Striped marlin). Blood samples have been collected from another five marlin. This study has the ambitious goals of (1) catching viable marlin, (2) tagging them successfully and (3) collecting condition data and tissue samples without affecting tagging survival. Our progress in each of these has been exemplary.



Having attached a PSAT to this healthy specimen of yellowfin tuna, NMFS scientists prepare to return the fish to the ocean.

Capture Success

Marlin fishing boat captains in the Kona region are to be highly commended for their efforts in helping this project. They have pledged not only their on-going support, but also the use of their vessels. Captains and crewmembers are being trained in the deployment of tags and data recording. Crewmembers on two of the Kona boats have had past veterinary training and have also volunteered to collect blood and tissue samples.

As an enticement to tag the marlin and be involved in the program, both marlin boat captains and paying fishermen are sent the PSAT results of the fish they have angled. This is proving very popular with the boat captains/owners and charter companies who are posting the PFRP data (marlin tracks) on their advertising web sites.

We have been receiving excellent collaboration with local commercial businessmen and tournament organizers. Marlin fishing tournaments such as: Hawaii International Billfish Tournament (HIBT), (Mr. Peter Fithian, Mr. Roy Moriokar), and Tropidilla productions (Mr. Jody Bright), whom collectively run over eight separate marlin fishing tournaments out of Kona alone. These tournament organizers have pledged support for the current project, and have included the deployment of PSATs as part of the competition. There will be national television coverage of the PSAT deployments during these tournaments.

Tagging

Blue marlin (*Makaira nigricans*) are angled from commercial sport-fishing vessels off Kailua-Kona. Either a scientist is present to attach the PSAT tag or attachment is performed by a trained crewmember. The PSAT tag is carefully deployed in the upper shoulder of the fish, approximately three inches below the third dorsal spine. The applicator needle is inserted to a depth sufficient that the tag head engages the pterygiophores. The tag heads have been modified with larger stainless-steel floppers for this purpose, and from all reports, they appear to be working well.

Sampling

If the marlin is small enough (100 lb.) and subdued, the tail can be gently lifted from the water and blood taken from the caudal artery. This is a two-man job and needs a willing helper to hold the bill of the fish underwater. Careful notes are taken on the capture and fighting behavior of the fish, which include the following factors:

- Line class
- Size of fish
- Duration of fight
- Depth of fight (Deep or surface)

- No. of jumps, greyhounds, or tail-walks
- Capture on bait or lure
- Hook position in jaw
- Time at the boat
- Color/ behavior at boat, and at release
- Fish bleeding/injured etc.
- Time, latitude, longitude

In addition to this, blood is also being sampled from moribund or recently killed blue marlin. The same data is recorded on the fight and behavior of the fish (blood is processed using the same technique). This gives us a huge amount of base line data, plus elevates the profile of the program to the marlin boat captains and the public.

Tissue Analyses

Moyes received the first shipment of billfish blood samples in early April and analyses are underway. We do not foresee significant technical problems. However, as we move from sharks to marlin, we need to develop several species-specific analytical techniques.

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

P.I.: Richard Brill, Yonat Swimmer, Mike Musyl, Lianne Mailloux Original P.I.: R. Brill, G. Antonelis, G. Balazs, and J. Polovina

Purpose of the Project

The objectives of this project are two-fold: 1) to provide reliable 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 deployed pop-up satellite archival tags (PSATs) on longline-caught and free-swimming turtles. PSATs record hourly data on swimming depth, water temperatures, and provide daily estimates of light-based geolocations. Because tags can be programmed to release up to two years after deployment, their use provides an opportunity to determine long-term movement patterns and their associated ambient environments. Collection of long-term data will, in turn, allow for the design of time-area fishery closures that are effective at reducing rates of turtle-longline gear interactions.

Progress During FY 2003

As documented previously, we maintained captive green turtles (*Chelonia mydas*) at the Kewalo Research Facility in order to identify a suitable technique for applying PSATs on hard-shelled turtles. Based on our initial findings, whereby PSATs stayed on turtles for up to one year in captivity, we selected a simple marine epoxy to attach a baseplate onto hard-shelled turtles. Since March 2001, we have trained over 80 observers in Hawaii, California and Costa Rica on attachment techniques on hard-shelled turtles, and in that time, PSATs have been taken to sea on approximately 360 longline fishing trips, resulting in approximately 4,500 observed longline sets throughout the North Pacific Ocean.

Due to fishing restrictions in the Hawaii-based swordfish fishery, opportunities to tag turtles in and around the Hawaiian Islands have been severely limited. To date, two turtles, an olive ridley (*Lepidochelys olivacea*) and a loggerhead (*Caretta caretta*) have been



Figure 1. Horizontal movements of an olive ridley sea turtle (#13202) caught and released from a longline fishing vessel. This turtle was successfully tracked for 4.5. months, and the data suggest the turtle's movements were correlated with the North Equatorial current.

tagged, but we have only retrieved data for the olive ridley that was deeply hooked in the mouth. A PSAT remained on this turtle for four months and provided data on horizontal and vertical movement patterns. Raw geolocation data were run through a state-space Kalman filter model (thanks to J. Sibert and A. Nielsen) in order to provide an estimate of the turtle's most probable track. We investigated the possibility that the turtle's movements were associated with oceanographic features. While no significant or strong correlations were found between turtle movements and sea surface temperature and chlorophyll fronts, the data suggest that the turtle's horizontal movements were correlated with the North Equatorial current (Figure 1). Regarding depth distribu-



Figure 2. Vertical movements of an olive ridley sea turtle (#13202) caught and released from a longline fishing vessel.

tion, the turtle spent the majority of the time within the mixed layer (100m), with the majority of daytime depths within the top 50 m (Figure 2). The second PSAT deployed on a loggerhead (*Caretta caretta*) appears to have shed from the turtle nearly immediately after the turtles' release into the water. We are uncertain as to the reason for the early shedding of this tag. In both cases, the tags were shed early, apparently due to a deficiency in either the tag or the method of attachment.

In order to circumvent the problem of getting too few tags out with the Hawaiian longline fishery, we joined forces with the Sea Turtle Restoration Program and PRETOMA in Costa Rica, where incidence of turtle bycatch is high. Since December 2001, we have successfully applied PSATs on 10 sea turtles (9 olive ridleys, 1 green turtle) in the shallow-set (<100m) mahi mahi (*Coryphaena hippurus*) longline fishery in the EEZ of Costa Rica. Seven of the animals were caught by longline, and three were captured while free-swimming. These later individuals served as controls (to estimate natural survivorship) to which the behaviors of longline-caught turtles could be compared. From the data obtained to date, turtles have remained at-liberty for approximately six to eight weeks, which is, however, considerably shorter than their programmed release date set at one year. We continue to investigate the problem of tag retention and have made both minor and major modifications to our attachment protocol in order to improve retention time.

The most probable horizontal movements of three longline-caught turtles (Figure 3) and three free-swimming turtles suggest similar movements for a six to eight week period. Based on these observations (from a relatively small sample size), movements of both longline-caught and control turtles do not appear to be different. From the vertical movement data obtained so far, there have been no apparent mortalities. Depth data suggest that both longline-caught and control turtles spend approximately 85% of the time during the day within the top 40 m. During the night, both



Figure 3. Horizontal movements of 3 longline-caught turtles tagged in Costa Rican waters. Numbers indicate number of days tag remained on turtle.

groups spent nearly 95% of their nighttime depths within the top 40 m, with control turtles spending 90% of that time within the top 20 m as compared to longline-caught turtles that remained slightly deeper. All olive ridley turtles around Costa Rica spent the majority of time in ambient water temperature at 26-28°C. The one green turtle tagged also spent ~95% of its day and night time depth within the top 40 m, and spent the majority of its time in slightly warmer water at 29°C. Once we collect more data of turtle movements, further analysis can be conducted to determine potential differences in turtle groups' directionality of movements, dive depth profiles and preferred water temperatures.

In September 2002, Y. Swimmer trained 12 observers assigned to the California-based longline fishery in PSAT attachment techniques. Since that time, observers have deployed five PSATs on loggerhead turtles caught and released from longline fishing gear. Tags are set to release in October 2003. Because this fishery has opportunities for tagging, we have since sent six more PSATs on observed longline trips. We plan to continue this arrangement with the California observer program and train more observers in Fall 2003. We have approximately 15 PSATs dedicated to this work.

We have also been involved in several other related turtle tagging projects. In association with colleagues on the mainland (Drs. Molly Lutcavage, Anders Rodin, Sam Sadove, and Russ Andrews), a method for attaching PSATs to endangered leatherback turtles (*Dermochelys coriacea*) released from longline gear is also now being tested. The method involves a subdermal attachment of the PSAT's tether using a medical-grade titanium bone anchor. During June 2002, Y. Swimmer joined colleagues on a leatherback nesting beach in Puerto Rico in order to test a direct carapace attachment method. During a one-week period, five females were successfully tagged. However, all five tags released to the surface within two months after deployment, approximately 6 months earlier than planned. Once again, we are investigating the possible failure mode and will modify our methods before another attempt at attaching PSATs on leatherbacks is made.

To date, none of the turtles appeared to have died during the first 6-8 weeks post release, the period of time for which the tags were attached to the turtles. All of the tags were shed earlier than planned. We will continue to investigate the reasons for the apparent early release of the PSATs.

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

P.I.: William A. Walsh, Keith A. Bigelow, and John Sibert

Purpose of the Project and Results

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 inter-specific CPUE for several species are correlated throughout the Pacific Ocean. This will entail 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 US mainland fisheries and possessions, and western Pacific fisheries. This work will continue and expand upon an earlier PFRP project (Distributions, Histories, and Recent Catch Trends with Six Fish Taxa Taken as Incidental Catch by the Hawaii-based Commercial Longline Fishery, by William Walsh and Samuel Pooley).

Progress During FY 2003

This project was funded in November 2002 and is in its preliminary stages. Since joining the project (in S.G. Pooley's stead), K.A. Bigelow has read and critiqued the proposal. Preparatory work has included collaboration with the NOAA CoastWatch/Hawaii Node and the NMFS Honolulu Laboratory ITS department regarding data acquisition and processing. Mr. David Foley (former CoastWatch manager), Mr. Lucas Moxey (current CoastWatch coordinator), and Mr. Richard Uyeda (current HL employee) have all contributed their time and expertise, which is gratefully acknowledged.

The initial analyses involve refitting generalized additive models (GAMs) to observer data in an effort to make them more meaningful and comprehensible. The data sets used are those corrected under the earlier project. The species of initial interest are blue marlin, mahimahi, and wahoo since these were part of the earlier project. Newly generated results (i.e., the refitted GAMs) are compared to those fitted previously to evaluate whether they represent improvements.

There have not been any specific problems per se. The status of this project reflects the dedication of efforts to completing some of the deliverables from the earlier project.

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

P.I.: John Kaneko and Paul Bartram

Purpose of the Project

Recognizing that fisheries products in the US market originate from multiple domestic as well as distant fisheries, a practical method for making objective, science-based assessments and comparisons of bycatch impacts is needed. The project objective is to evaluate the incidental catch of non-target fish species and sea turtles in Hawaii's longline fishery and make comparisons with other pelagic longline fisheries in a methodology patterned after Hall. The purpose is to put the bycatch associated with the Hawaii pelagic longline fishery into perspective by using a comparable standard of ecological impacts to make comparisons with other fisheries for the same target species available in the US seafood market. Pelagic longlining is not a single method, but many methods differentiated by their operating characteristics. In order to make meaningful comparisons of fish produced by vessels applying the different longlining methods on a ton-for-ton basis of marketed species, the ratio of BPUE (bycatch per unit effort) to CPUE must be calculated. This allows a practical measure for comparison by relating bycatch impacts per unit of the targeted catch. By doing so, the relative ecological trade-offs can be quantified when management actions promote shifts in fishing effort and shifts in the source of the market supply of the same species.

Progress During FY 2003

The project work began July 1, 2002 after funds became available.

Gathered and reviewed literature on bycatch, responsible fishing and ecosystem-based management as background for approaching the project and establishing definitions.

Collected information needed to describe the typology pelagic longline fishing methods. The typology profiles include details about the gear, the configuration, the number of hooks, the types of hooks and bait, etc. How gear is configured and used has a great impact on bycatch rates and impacts, especially on sea turtles. These details help to distinguish the various methods so that comparisons of bycatch rates between Hawaii methods and other fisheries can be better understood. These profiles have been assembled and efforts are ongoing to have their accuracy confirmed by people in positions to verify the information.

Efforts were made to determine the major sources of fresh swordfish imported into the US through the major ports of entry. A long-list of leading exporting countries was considered for potential comparisons with Hawaii's fishery. Work was done to estimate sea turtle take rate for western tropical Pacific tuna longliners, Brazil swordfish longliners and Costa Rica mahimahi longliners. Bycatch per catch ratios were estimated and comparisons of bycatch per ton of target species were made with product from the Hawaii fishery to estimate the magnitude of the differences of potential incidental interactions of sea turtles.

The PI's participated in the Second International Fishers Forum (IFF2) in November 2002 to make contacts with fishermen and fisheries scientists from around the world who are working on solutions to bycatch problems associated with pelagic longline fishing. Met with Martin Hall from IATTC and made other contacts from important countries including Mexico, Chile, Brazil, Taiwan, Costa Rica, Mexico, South Africa, SPC, etc. Follow-up efforts with these contacts have helped to gain perspective on how longline gear is configured and used in the various fleets. We have also been trying to determine if fisheries data on primary catch and bycatch are available in these countries. This type of information is not readily available but efforts are continuing.

Paul Bartram gave a progress report presentation on December 5, 2002 at the PFRP PI's meeting.

A short-list of fisheries to be compared with Hawaii's fishery has been prepared by interviewing major buyers of Hawaii swordfish that had to replace their supply with imported swordfish. The short-list consists of California, Mexico, Panama, Costa Rica and South Africa, the actual source of swordfish these major buyers used after the Hawaii swordfish supply was eliminated and the buyers were forced to substitute imported product. The short-list is needed to attempt to quantify the ecological trade-offs that might have occurred as a net effect resulting from the Hawaii swordfish fishery closure that was intended to reduce adverse impacts on sea turtles.

Problems

Accessing fisheries data especially on sea turtle bycatch and fish discards from countries that have pelagic longline fisheries has been very difficult. Information is limited, but by using the longline typologies and information on the type of fishing methods used in the various fleets, we have a method for estimating the potential bycatch impacts. Efforts are continuing to access data through industry and management contacts.

Causes of Rapid Declines in World Billfish Catch Rates (revised to "Reconstructing Ecosystem Dynamics: The Long-term Effects of Exploitation on Apex Predators in the Open Ocean")

P.I.: Ransom A. Myers

Purpose of the Project

The research aims to identify key processes that influence the responses of pelagic fish populations to exploitation by longline fishing gear. PFRP funding was scheduled to commence in January 2003.

Quantitatively describe the pelagic fish communities of the open ocean when longline fishing commenced.

Preliminary analyses of survey data indicate that the pre-exploitation population size of pelagic fish in the open ocean was much larger than previously believed. The analyses are based on detailed scientific survey data, which predate the time-series of commercial fishing data that are routinely used in stock assessment.

Of significance are data from longline surveys during the 1950s and from observers deployed on commercial longliners since about 1980. Abundance indices derived from those data sets must be adjusted for the effects of variations in the timing of longline operations, the quantity of hooked fish removed by scavengers, gear saturation and bait loss.

Identify spatial and temporal patterns in the distribution, abundance and size composition of the populations comprising those communities.

The standardized longline data will be used to describe spatial and temporal patterns in the populations from the 1950s through the present. General patterns, if they exist, will be highlighted by comparison of trajectories in different areas (e.g., central tropical Pacific compared to the Gulf of Mexico and north-western Atlantic). Population attributes will include size composition and species abundance. Abundance will be considered in terms of number of individuals and also as biomass derived from species-specific length-weight relationships applied to length data.

Test hypotheses that might explain the observed patterns.

The analysis of patterns in the populations will point to key processes that influence the responses of pelagic fish populations to longlining. Those processes will be linked to testable hypotheses. Because they are an output of the pattern analysis, we are not yet in a position to identify exactly what hypotheses will be investigated. Examples of hypotheses that might be investigated include density dependent habitat selection, competition between fishing gear and population sub-structuring.

Progress During FY 2003

Quantitatively describe the pelagic fish communities of the open ocean when longline fishing commenced.

Compilation of observer, survey and historical catch and effort time-series are largely complete. We have fivedegree square – month Japanese longline data for 1952-99 in the Pacific and Indian Oceans and for 1952-99 in the Atlantic Ocean. We do not have access to finer, set-by-set records. However, they exist only since the mid-1970s, which is later than the period of particular interest to the current project.

We have assembled databases for observers on longliners in the central and North Pacific (observers on Hawaiibased longliners), western Pacific (SPC observers on various longliners), the South Pacific (Australian observers on Japanese longliners) and western Atlantic and Gulf of Mexico (US observers on US and Japanese longliners).

We have survey data from the Pelagic Fisheries Oceanic Investigations (POFI) during 1950-53 and recently came across a similar, though smaller data set for the Eastern Pacific during the late 1950s. Monthly length frequency data have also been obtained in hard copy form for Japanese longliners in the Pacific during the 1950s.

We are currently assembling data on the status of each hook at retrieval (bait intact, bait missing or hook broken off) for the central tropical Pacific (1950s and 1990s) and the Indian Ocean (1990s). The data are limited to the 1950s POFI surveys, Townsend-Cromwell research surveys during the 1990s and an Indian Ocean observer program. Those data are in hard copy and are currently being entered into an electronic database.

We have completed analyses of the effects of timing and soak time on abundance indices. The analyses reveal that abundance estimates are strongly influenced by soak time and also by the timing of longline operations in relation to dawn and dusk. Longline catch data will underestimate the total mortality of several species because the animals are lost from the longline before retrieval. In contrast, soak time has a strong positive effect on the catch rates of most shark and billfish species. At the beginning of longline retrieval, for example, swordfish catch rates are four times those at the end of retrieval.

The original motivation for examining the effects of soak time was the expectation that soak time had increased as a result of increases in the number of hooks per operation since longlining commenced. However, the analyses indicated that soak time actually declined, resulting in an underestimation of the catch rates of many species in recent years. More significant may be changes in the timing of longlining operations. A shift from operations that spanned both dawn and dusk to operations concentrated more on dusk may have moderated the effects of reduced soak time for many species.

We have commenced analysis of the effects of depth and shark damage on abundance indices. Those analyses include a comparison of observed catches and those predicted by habitat models.

Identify spatial and temporal patterns in the distribution, abundance and size composition of the populations comprising those communities.

We are about to submit for publication a comparison of early 1950s and 1990s pelagic fish communities in the central tropical Pacific Ocean. That analysis, which takes into account the effects of variations in soak time and longline depth, shows substantial declines in the species that were initially most abundant, e.g., yellowfin tuna, oceanic whitetip shark and silky shark. Several species show increases, e.g., skipjack and snake mackerel. The early surveys were conducted as controlled experiments with longline gear and techniques held constant throughout the study. Survey longlines were deployed in a grid at pre-determined stations spaced one-degree apart. Searching for target species is an important difference to be considered when comparing survey and commercial catch rates. Unless the effects of improvements in efficiency and searching can be accounted for, the catch rate estimates for the early surveys must be considered minimums.

Test hypotheses that might explain the observed patterns.

Hypotheses are yet to be identified. Examples of conceptual models have been developed.

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

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

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 2003

Meetings

The first meeting of the project PIs was held in Honolulu in July 2002. All four PIs were present. The implementation of the program was discussed, including sampling, laboratory analysis, database standardization, staff, administration and priorities. Project funds were not used to finance this meeting.

The second PI meeting, funded by the project, will take place in Noumea from April 28 to May 2, 2003. The four PIs, a collaborator Brian Fry and a Ph.D. student Brittany Graham will attend. Progress and problems will be presented and actions for the following year prioritized.



Cannibalism: 2 small lancetfish (Alepisaurus sp. -33 and 22 cm SL) found in the stomach of a 143 cm lancetfish caught on a longline in New Caledonia EEZ in July 2002. Photo courtesy Valerie Allain.

Funding

Administrative difficulties hindered transfer of first year project funds to SPC until March 2003. SPC received \$29,765 USD and the full amount was transferred to CICIMAR and IATTC in April 2003. This delay in receiving funds caused the initiation of at-sea sampling efforts in the eastern Pacific to be delayed. CICIMAR and IATTC are subcontracted by SPC, and the SPC-CICIMAR-IATTC year 1 budget is \$102,176 USD. It is not known when the remainder of the year 1 budget will reach the PIs. Funds were available to the UH beginning January 2003.

SPC funds were used to implement sampling and analysis in the western/central part of the Pacific while waiting for funds to become available from PFRP. SPC has been working on a trophic-ecology project in the western Pacific since September 2000.

Sampling on tuna vessels

Western/central Pacific

In the western/central Pacific, observers collected samples from the National Observer Programs of the area. Sampling kits were distributed to Papua New Guinea (8 kits), Fiji (5), Federated States of Micronesia (2), Solomon Islands (5), Marshall Islands (1), Kiribati (5), Cook Islands (4), French Polynesia (11) and New Caledonia. 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 July 2002, 17 sampling trips have been completed: 4 longline trips in New Caledonia, 8 longline trips in French Polynesia, 1 longline trip and 1 purse seine trip in Papua New Guinea, 1 purse seine trip in Federated States of Micronesia, and 1 longline trip and one trolling trip in the Cook Islands.

Of the 750 stomachs collected from 43 species of predatory fishes, 504 have been examined in the laboratory. The most numerous predatory fishes species are yellowfin tuna (71 specimens), bigeye tuna (30), skipjack tuna (47), albacore (50), blue shark (15), silky shark (10), wahoo (32), lancetfish (*Alepisaurus ferox*) (32), dolphinfish (38), moonfish (22), escolar (11), and rainbow runner (22). The data have been entered in a database, but not yet analyzed.

Trophic level of the predators will be estimated by using the stomach contents as well as stable isotope analysis of the muscle and liver samples. From the 746 muscle and 748 liver samples collected, 185 and 185 samples, respectively, were freeze-dried for isotopic analysis. We will also use the stable isotope analyses of plankton, prey and predators to establish an isotope-derived biogeography.

In Hawaiian waters, under the primary objectives of the PFRP project, 340 samples were collected from Hawaiian FADs and Cross Seamount. Samples collected include stomach contents and tissue samples for isotope analysis from bigeye and yellowfin tuna. Results of analyses of these samples will allow us to better link data from the western and eastern Pacific.

Eastern Pacific

In contrast to the western Pacific, a sampling program using observers on tuna vessels in the eastern Pacific Ocean (EPO) was not in force prior to this PFRP project. During this fiscal year, project PIs made two trips to sampling ports in the EPO, one to Manta, Ecuador and one to Mazatlán, Mexico, and laid the groundwork for sampling by observers. On both trips, vessel owners and cannery officials were given information on the study and their cooperation for cutting tunas at sea was requested and obtained. Training sessions were held for IATTC office personnel and observers who were in port. An observer manual was prepared containing species identification guides and sampling guidelines. Sampling equipment and supplies for the first year of the project were purchased using IATTC funds, and shipped to Ecuador and Mexico.

No trips have been completed nor samples obtained by observers as of the drafting of this report. Samples have been taken, however, from 2 yellowfin, 3 bigeye, and 1 skipjack tuna that had been tagged with archival tags by the IATTC in the EPO. The data from the archival tags will provide a record of the movements of these particular fish. Once progress has been made in defining an isotope-derived biogeography in the pelagic tropical ecosystems, the movement patterns inferred from the stable isotope markers in the liver and muscle samples of these tuna will be compared to the tag-derived movement records. Samples from archival-tagged tunas will continue to be collected during subsequent years of the project, providing a means to ground truth hypotheses regarding large-scale tuna movements.

Sampling on research vessels

Western/Central Pacific

During 2 exploratory trips in the EEZ of New Caledonia, 17 samples of particulate organic matter (POM) and 56 samples of zooplankton were collected using plankton nets of different mesh-size. These samples were frozen and sent to the UH for isotope analysis. During these trips, pelagic prey organisms were also collected using a pelagic trawl. About 190 samples of small fish, squid and crustaceans were stored frozen. These samples will allow an evaluation, based on isotope values, of the intermediate trophic levels occupied by these prey.

Eastern Pacific

Preparations are being made for sampling POM and zooplankton in conjunction with the *Stenella* Abundance Research Project (STAR) of the NMFS, La Jolla, California. 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 tropical Pacific. Two research vessel cruises will take place simultaneously during July-December 2003, and will survey a large portion of the eastern and central Pacific (for cruise track please see <u>http://swfsc.nmfs.noaa.gov/prd/star/</u><u>default.htm</u>). Oceanographic data will be collected on these cruises. NMFS scientists have agreed to collect samples of POM, zooplankton, and various fishes and invertebrates for this PFRP project.

Sampling to analyze within-fish isotope variability

Systematic samples were collected from tuna to examine within-fish isotopic variability. This is an issue because the initial sampling design calls for sampling muscle from the dorsal area of purse-seine-caught fish, but from the belly region of longline-caught fish, and it is necessary to confirm that the data from these two loci are comparable. Samples of muscle from different regions of the body, liver, stomach wall, gill, and eye were taken from 2 large yellowfin tuna in the western Pacific and 1 large, 1 medium, and 1 small yellowfin in the eastern Pacific. The specimens from the western Pacific were freeze-dried and sent to the UH for analysis.

Isotope analysis

All samples received from the western Pacific and the 340 samples from the central Pacific are in the process of being lipid extracted or homogenized before stable isotopic analysis. The carbon and nitrogen isotopic composition have

been determined on nearly 100 of the lipid-extracted tissue samples. Much time in the laboratory has been devoted to logistics of sample preparation and analysis. Four general findings from the stable isotope analyses have nonetheless emerged:

- 1) Liver, red, and white muscle tissues are isotopically distinct in juvenile tuna and show constant offset in their isotopic values. The implication of this result is that any one of these tissues can be use to characterize the isotopic composition of an individual.
- 2) Juvenile tuna are isotopically similar at 5 different FAD locations; however, one subset had a uniquely high signature relative to others of comparable size. The uniquely high isotopic values could be explained by (a) a different nutrient source feeding the plankton at the base of the food web fed upon by this school, (b) starvation, or (c) cannibalism of young tunas.
- 3) Adult yellowfin and bigeye tuna collected from Cross Seamount have isotopic signatures nearly two trophic levels higher then the nearshore Hawaiian juveniles.
- 4) Initial results from the western Pacific show that nitrogen isotopic values for bigeye are greater than those for yellowfin tuna.

Laboratory experiments

A tuna tank to be built for feeding experiments is not yet complete. Dr. Kim Holland has suggested that the outdoor tank will be built and ready for preliminary testing by early summer 2003. We hope these feeding experiments will allow us to measure differences in the isotope composition of slow- and fast-turnover tissues, which should provide a more refined view of tuna movements. For example, by comparing isotopic compositions of tissues with different turnover rates from tunas caught in the open ocean, we hope to be able to estimate the number of days since diet switching due to migration from one feeding area to another.

Names of students graduating with MS or Ph.D. degrees during FY 2003

No students have graduated. Ms. Brittany Graham was accepted in the Ph.D. program by the Department of Oceanography, University of Hawaii in September 2002. Ms. Graham is supported by a PFRP fellowship/graduate assistantship and is working jointly between this project and PFRP project 757282 of Holland et al.

Developing Methods to Assess Sex and Maturational Stage of Bigeye Tuna (Thunnus obesus) and Swordfish (Xiphias gladius)

P.I.: E. Gordon Grau

Purpose of the Project and indicative results

A comprehensive understanding of the reproductive biology and spawning activity of the tuna is necessary for sound management of this complex and important fishery. Current methods for assessing maturity schedules of tunas is based on the conventional approach of collecting gonads for detailed histological examination. While this method has proven to be accurate and provides valuable information, it is labor-intensive, expensive and lethal for the fish. In addition, this conventional approach is completely unsuitable to fishery-dependent assessments, since gonadal samples are often unavailable. The most challenging feature of the histological approach is that it is time consuming, thus making it impractical to evaluate the population annually. As a result, management models are static and fail to reflect 'real-time' effects of fishing pressure or environmental perturbations.

The central aim of this proposal is to develop accurate, simple to use and economical tests to determine sex and maturational stage of bigeye tuna and swordfish so that populations can be monitored on a regular basis and at low cost. We proposed the following objectives to achieve this goal:

- 1) Develop and modify existing biotechnology to identify the sex and maturational status of individual fish in two species: bigeye tuna (*Thunnus obesus*) and swordfish (*Xiphias gladius*). Our approach will focus on sex determination by gonadal steroids and maturation specific compounds present in blood and muscle tissue samples.
- 2) We will use yellowfin tuna (*Thunnus albacares*) as a model. We will develop highly sensitive radioimmunoassays to identify sex-specific hormones and proteins present in blood and muscle samples. Antisera and specific immunoassays will be created for tuna vitellogenin, the egg-yolk precursor specific to maturing female fish.

- 3) Validate the accuracy of this approach by 'ground truthing' the results with the standard method of staging maturity based on histological examination of the gonads. We will also try to identify sex-determining gene in the tuna.
- 4) Transfer the new technologies to fishery biologists throughout the Pacific for use in constructing and monitoring maturity schedules for bigeye tuna and swordfish.

Progress During FY 2003

Field Collections

A major problem encountered during the initial part of FY 2002, and as a carryover from previous years, was obtaining high quality blood serum samples to use in validating and establishing the radioimmunoassay for this project. Our initial attempt to use blood collected from fish previously caught by fishermen and sampled at the pier produced disappointing results. We discovered that high quality serum could only be obtained from fresh animals. Fresh blood can only be obtained from fish sampled immediately after being caught. This eliminated the possibility of obtaining samples from fishermen and forced us to put more time, energy and money into collecting our own fresh fish for sampling. A cooperative agreement was established with the Medical Foundation for the Study of the Environment (MFSE) and, with the assistance of JIMAR funds, several fishing expeditions were successfully conducted in FY 2001.

Plasma and tissue levels of estradiol

As mentioned above, the current methods for assessing sexual maturity in tunas is reliant on collecting gonads for detailed histological examination. This method is accurate but is lethal to the fish. We undertook studies in FY 2002 to determine sexual maturity by measuring levels of estradiol in the plasma and muscle of tunas. During the previous fiscal year we analyzed blood and muscle tissue for plasma. As reported in FY 2002 progress report we found significant amounts of E2 in the plasma and muscle in both female and male bigeye tuna, swordfish and yellowfin tuna.

Our observation that male tunas have significant levels of E2 prompted us to look at another species, the tilapia, to ascertain if males in other species of fish have significant amounts of E2 in the plasma.

Plasma concentrations of E2 in male tilapia were determined by RIA using a commercially available kit with modifications (Immuchem Double Antibody Direct Estradiol RIA kit). The validity of the assay was assessed by demonstrating that parallel displacement curves are generated with serial dilutions of plasma samples and also with stripped plasma. In the preliminary experiment, dilution of neat plasma from the male tilapia was not parallel with E₂

standards. The plasma was then extracted with ether, following the procedure established for the angelfish plasma. Briefly, 2 ml of ethyl ether was added to plasma sample. The tubes were vortexed and frozen at -80°C for 10 min, and the aqueous organic layer was decanted into a new glass tube. The ether extract was evaporated to dryness in a water bath at 40°C for 1 hour, and then placed under nitrogen for 5 min to ensure complete evaporation. Extracts were then reconstituted with 50 ml assay buffer. As shown in Figure 1, serial dilution of the ether-extracted plasma was parallel with estradiol standard indicating the presence of estradiol in the male fish.

In order to confirm further the presence of estradiol in the male fish, estradiol was extracted from 200 ml of plasma from the male tilapia with Sep-Pak C-18 Light cartridge. In a preliminary experiment, we have confirmed that ³H-estradiol was eluted in fractions between 25-35% acetonitrile through the cartridge (Figure 2). Briefly, the cartridge, preconditioned with 2 ml of 2-propanol and 2 ml of 0.1% aqueous trifluoroacetic acid (TFA), was loaded with the plasma sample. The cartridge was washed with 2 ml of 0.1% TFA, followed by 2 ml of 25% acetonitrile in 0.1% TFA. Estradiol was eluted with 1.5 ml 40% acetonitrile in 0.1% TFA, and evapo-



Figure 1. Displacement curves for estradiol and serial dilutions of plasma from the male tilapia. Diamonds represent estradiol-17b standards. Open circles represent diluted plasma after ether extraction. Closed circles represent diluted plasma after acetonitrile extraction Sep-Pak C18 cartridge purification.



Figure 2. Elution profile of 3H-estradiol through Sep-Pak C18 cartridge. 10 mCi 3H-estradiol in 10 ml ethanol was diluted with 250 ml assay buffer and added to the cartridge.

rated to dryness using Automatic SpeedVac. The dried residue was reconstituted with 250 ml of assay buffer. In the preliminary experiment, 10 mCi of ³H-estradiol ([2, 4, 6, 7, 16, 17-³H] oestradiol) in 10 ml ethanol was diluted with 250 ml assay buffer, and added to the cartridge. As shown in Figure 2, estradiol was eluted in fractions between 25% and 35% acetonitrile.

Finally, we demonstrated that acetonitrile extracted plasma was parallel with estradiol standard (Figure 1), further indicating the presence of estradiol in the male tilapia.

Plasma Vitellogenin

One of the problems we encountered this past year is the difficulty in inducing vitellogenin (VTG) production in tunas. Efforts are ongoing to experimentally induce VTG in juvenile tuna as a standard for the enzyme-linked immunosorbant assay (ELISA). The challenge lies in capturing and maintaining juvenile fish for the duration of the experimental treatment (5-7 days). We

decided to use the tilapia as a model to establish the VTG ELISA in our laboratory. We recently established a homologous VTG ELISA using a "universal" antibody for fish vitellogenin. We have found that male tilapia contain low levels of VTG in the plasma (0.008 mg/ml). These levels however, are 400-500 times lower than that observed in females (3.6 mg/ml). Similar findings have been observed in other teleosts species. Why males appear to have detectable levels of plasma VTG has not been investigated.

Development of Oceanographic Atlases for Pelagic and Insular Fisheries and Resource Management of the Pacific Basin

P.I.: Russell E. Brainard, John Sibert and Dave Foley

Purpose of the Project

The development of broad-based ecosystem approaches to fisheries management is hindered by the bewildering array of oceanographic information currently available. Additionally, there is no consistent coding or formatting standards, and each data source may require different software for access. The Pacific Ocean Atlas project is designed to provide environmental data from a variety of platforms (satellite, shipboard, moorings, and numerical models) in forms useful and accessible to both non-expert and expert users. These data will be provided in a series of oceanographic atlases for all of the U.S. Pacific Island exclusive economic zones (EEZ) and regions of the Pacific basin important for pelagic and highly migratory species fisheries management. Distribution of the full data sets will be conducted primarily over the Internet. Both CD-ROM and limited print versions will be made available for resource managers and researchers in those areas lacking the resources for large Internet transfers.

Progress During FY 2003

Time Series and Climatologies

The development of science-quality historical time series and climatologies is one of the fundamental goals of the project. For each ocean parameter, there is an analog in the near real time data sets handled by CoastWatch on an operational basis. However, many of the data sets required more handling and assembly than had been expected. This process is now complete for all data sets through the end of year 2002. Acquisition of subsequent data will likely require coordination with the new management of the Hawaii CoastWatch site, though there may be a number of alternatives emerging within the next 12 to 24 months.

New Derived Products

- Failed to produce a proxy for the "deep scattering layer"
- Poorly defined concept
- Sample data sets in-house but not available

- Requires very time-consuming calculation of underwater light field
- Completed development of value-added products specified by users in 2000/2001:
- Vertical shear of current from Ocean Model/Data Analyses,
- Thermocline Depth for the tropics,
- Surface Ocean Currents from Satellite.

Personnel

The first atlas Coordinator, Mr. Ramzi Mirshak, left the program to return to graduate school in August 2002. Mr. Lucas Moxey was recruited and hired November 1, 2002, to replace Ramzi. Before finishing training, Mr. Moxey moved in February to fill the Hawaii CoastWatch Coordinator position vacated by Foley. As such, he was able to make only a minimal contribution to the project. The hiring process was initiated once again, and Mr. Russell Moffitt was brought on as the new Atlas Coordinator in late August 2003.

Data Sets

In situ data

Incorporation of existing *in situ* data sets with the rest of the Atlas data has required a significant amount of attention. While oceanographic data sets, such as COADS and Levitus, provide "highly refined" products, the averaging and interpolation methods employed were generally formulated to examine scales relevant to climate studies and not those necessarily relevant to fisheries and living marine resource management. It is likely that these data sets will adequately provide the larger scale context within which the finer scale information, when available, can be more effectively analyzed. Additionally, the atlas project has searched for and attempted to include other sources of reliable *in situ* oceanographic data. The project is making efforts to obtain the US Navy Master Oceanographic Observations Data Set (MOODS), though much of this data is classified, complicating the acquisition process. Even with all of the available oceanographic data, these regions are generally extremely sparse and not sufficient to describe the physical environment at the level required for most ecosystem based population models.

Remote Sensing Data and Model Output

Derived Properties

In an effort to meet user needs, input was solicited from the members of the Methods Working Group, at the 16th meeting of the Standing Committee on Tuna and Billfish (STCB) in Honolulu, HI. The most interest expressed concerned the use of model reanalysis products (coupled geophysical models which assimilate observations of a broad range of parameters).

A useful pertinent derived product dataset has become available, Ocean Surface Current Analyses – Real time (OSCAR). OSCAR infers ocean surface currents from a combination of dynamic topography (geostrophic currents) and surface wind stress (Ekman transport). Mesoscale geostrophic flow is derived from TOPEX/Poseidon sea surface height data, while mesoscale wind-driven currents are derived from QuickSCAT vector wind fields.

Web Site

Development has begun on a rudimentary web interface to the atlas data. Initial work has focused on providing interactive access to climatologies and timeseries of *in situ* and satellite datasets.

Developing Biochemical and Physiological Predictors of Long Term Survival in Released Blue Sharks

P.I.: Christopher D. Moyes

Purpose of the Project

For catch-and-release sports fishing and non-retention of commercially caught fish to be justifiable management options, there must be a reasonable likelihood that released fish will survive long term. At present, there is no scientific basis for making this prediction for any large pelagic fish. Therefore, even when recreational anglers and commercial fishermen practice good catch-and-release fishing, high rates of delayed mortality are a distinct possibility. Tag-and-release programs are important tools to assessing post-release survival, but they can be difficult and expensive to

implement. Conclusions from tag-and-release studies are rarely extrapolated to other species because of the many factors (e.g. size, water temperature, fight time and fishing gear) that may influence survivability or mortality. We propose a novel approach to study the basis of post-release mortality. Rather than assessing how many fish survive, we try to understand **why fish die**. We are developing a set of diagnostic tools to assess the biochemical and physiological status of sharks caught by longline on scientific cruises. These tools are being developed in combination with pop-off satellite archival tag (PSAT) data to establish predictors of survival.

We have focused on assessing the extent of tissue damage arising from capture using comprehensive analyses of ions, metabolites and proteins found in the plasma. For example, the damage to myocardial tissue upon a heart attack causes release of proteins such as creatine phosphokinase and troponin I into the plasma. 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 2003

Milestones

We have almost completed the analyses of the shark data. I am preparing a manuscript based on these analyses in conjunction with mortality data obtained from tagging studies.

Problems

There have been no significant technical problems to date. Unfortunately, there seems to be a rather high rate of premature release, likely due to nuptial bites.

Accomplishments

4/2002 Cruise. During the twenty-nine days at sea, nineteen longline sets were made, with over 9,000 hooks set. A total of 207 fish and sharks were caught. Forty-seven percent of the animals snared on the longline were blue sharks (98 individuals) and 26 of these animals were landed. Of the 26 sharks landed, 2 sharks were dead while the rest were tagged with PSATs (18 individuals) or conventional tags (5 individuals) before release. Blood samples were collected from 16 of the 18 PSAT tagged sharks, as well as all the conventionally tagged animals and the two dead animals. Thus blood samples were collected from a total of 24 blue sharks. Blood was also collected from three oceanic white tip sharks that were tagged with PSATs and released. Samples were processed at Kewalo Basin and prepared for transport to Queen's University for analyses.

7/2002 Conference: I presented our preliminary results at American Fisheries Society meeting in Vancouver.

11/2002 Cruise. Technician N. Fragoso worked on a two week cruise tagging sharks and billfish.

12/2002 PI meeting. Fortunately, I was able to attend the December 2002 PFRP meetings, which normally collide with my teaching schedule.

Throughout the entire fiscal year we are actively analyzing samples that have been collected from a total of 3 cruises (4/2001, 4/2002, 12/2002). The analyses continue and I expect to have a paper submitted on the biochemistry and tagging work by June.

RESULTS TO DATE

1. PSATS

Complete information on the status of the PSATs can be found in the progress report from Musyl and Brill. The PSAT approach has provided good data on survival of released sharks for at least a short period. The data suggest that the majority of released sharks suffer little delayed mortality. 102 105 107 108 109 110 113 114 116 118 117

2. Plasma analyses

Plasma analyses have been performed on more than 50 sharks.



Figure 1: HSF/U MKINA levels in dive shark bloba.

3. Molecular analyses

We are very excited about the results we are obtaining with the analyses of heat shock proteins. Using comparative genetic analyses, we developed a set of blue shark-specific HSP70 primers suitable for amplification of a cDNA probe. This allows us to measure levels of HSP70 mRNA levels. RNA was purified from blue shark erythrocytes from the 2001 and 2002 cruises. An example of our northern analyses is shown in Figure 1, illustrating the variation in HSP70 mRNA in several sharks (Note the darker bands in shark 102, 117, 118).

Economic Fieldwork on Pelagic Fisheries in Hawaii

P.I.: Sam Pooley and Minling Pan (started from November 2002)

Purpose of the Project

Part A: Longline

The main objective of the project is to resurvey the Hawaii-based domestic longline fleet to provide revised baseline data for conducting regulatory impact analyses on forthcoming regulations. This project is to extend the work initiated in 1994 with a thorough survey of the Hawaii-based domestic longline fleet, small-boat pelagic fishing vessel and charter fishing boats.

Part B. Blue Marlin Valuation

The main objective of the project is to study small-boats, charter-boat, and tournament anglers to elicit explicitly non-market economic values for blue marlin using standard contingent valuation techniques.

Progress During FY 2003

The re-studying project interviewed 62 vessels, about half of the fleet, during 2000-2001 on their 2000 vessel operations through person-to-person interview with vessel owners, captains, and crew. A report based on the study was completed and published (JIMAR contribution 03-348) in 2003. The report includes 1) an updated baseline of cost-earnings information for the Hawaii-based longline vessels, 2) identification of critical economic differences between 1993 and 2000, 3) costs to fishermen to switching target from swordfish target and tuna target, and 4) some economic aspects of fishing behavior in the longline fishing vessels. The study and report were prepared by the UH JIMAR staff.

Even though, these 62 vessels are a significant portion of the Hawaii-based longline fleet, about 50% of the fleet size in 2000, the majority of Vietnamese-American operated vessels have not yet been interviewed because of the language barriers in communicating during in-person interviews and the fact that some vessels left Hawaii to California to continue swordfish fishing due to the federal ruling of prohibition of swordfish fishing.

Distribution, 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 (Samuel G. Pooley ceased active involvement in this project upon assuming the directorship of the Honolulu Laboratory)

Project Purpose and Results:

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

Progress During FY 2003

Recent activities under this project have focused on producing the deliverables. A paper that summarizes the conceptual basis and methods employed under this project has been submitted and will be revised according to reviewers' recommendations. A second paper that presents corrected catch rates for blue marlin, obtained by development of

a generalized additive model from observer data and subsequent application to logbook data from unobserved sets, is in preparation (this manuscript should be ready for its internal reviews and possibly submittal before the end FY 2003). Preliminary efforts to improve linkage between observer, logbook, and auction data have also been conducted; Mr. Gerald Epstein (former HL employee), Mr. Frank Cabacungan, Mr. Dios P. Gonzales and Ms. Karen Sender (current HL employees) have all contributed their time and expertise in this context. Ms. Sender, in particular, has improved an error reporting and documentation system for the observer data and thereby facilitated collaboration between the Honolulu Laboratory and the observer program regarding data accuracy. She has proposed that such a system be "genericized" for use with the logbooks, in which case documentation of logbook data quality concerns should be similarly facilitated. Mr. Thomas Swenarton has been the participant from the observer office, and his efforts are also gratefully acknowledged.

No specific new problems have been encountered in FY 2003. The most common temporary diversions have consisted of the need to perform preliminary evaluations of observer data when these records become available; the checks generally require several workdays each quarter after the data releases.

Recreational Meta Data Project

P.I.: Paul Dalzell and Stewart Allen

Purpose of the Project

The Recreational Meta-Data Project was initiated to document and compile, into database format, sources of Hawaii's pelagic recreational fishing information. Though no official record of Hawaii's recreational fishery sector exists, many resources are available in the form of surveys, previous studies, club records, newspaper articles, and fishermen logbooks. This project provides fisheries managers and scientists a convenient way to access previous research on recreational fisheries as well as the raw catch and effort data of recreational fishermen throughout Hawaii.

Progress During FY 2003

During the first half of the fiscal year, progress was retarded by a lapse in the employment of full time personnel dedicated solely to this project. A field biologist, Jennifer Schultz, was hired in January 2003, to establish rapport with recreational fishermen, continue data collection, and maintain the databases and website.

Recreational fishermen have reacted positively to her effort to attend tournaments and club meetings, resulting in a reciprocal exchange of information. Several new contacts have been made in the past year. The clubs and tournament organizers who have donated information have received graphic summaries of their catch data, and many of these have been distributed to participants or included in newsletters. In response to requests for further information,

we have also provided applicable research papers, notifications of upcoming legislation and news articles via email or presentations at monthly club meetings.

Additional information will be accessible to fishermen, fisheries managers and scientists via our website launched on April 30, 2003. Over 70 surveys, papers and reports have been compiled and made available in PDF format with tables in attached spreadsheets. Our hope is to facilitate the review and incorporation of past research in future studies. The website also includes a short history on recreational fisheries in Hawaii, a contact page and a summary of the database, which is available

Catch Report Boat Name	Team #	
Marlin- Area Circle: Blue Black	Weight Striped Spearfish	Tag and Release
Ahi- Area Ono- Area Mahi- Area	Weight Weight Weight	
All other fish Total gross tonnage	Weight Weight	

Figure 1: Portion of catch report from Tournament 10. The entry for "all other fish" may contain multiple, unspecified fish, leading to difficulty in establishing an accurate number of fish caught and CPUE.

for use by researchers upon request. (A signed agreement to maintain the confidentiality of all clubs and tournaments will be required.)

Radio logs, catch records and weigh-in summaries from eight annual tournaments and monthly tournaments from two clubs were added to the database this year. The new additions are representative of the variety of tournaments held in Hawaii: six professionally organized tournaments with corporate sponsorship, two club sponsored jackpot tournaments with registration fees awarded as prize money, and two monthly club tournaments awarding only points toward an annual competition. Two new sources of recreational fishing data were also added to the database this year: daily charter boat weigh-in summaries generated by two small boat harbors and annual catch statistics as reported by the charter boats to the Hawaii Division of Aquatic Resources (HDAR). The database now consists of a total of 36 annual tournaments on four islands, the monthly tournament records from three local clubs, and charter boat catch statistics from two small boat harbors and HDAR.

Though the tournament records do provide insight into the nature and scope of Hawaii's pelagic recreational fishery, the data may be compromised by inconsistent or tournament-specific reporting. For example, Tournament 10

offers a cash award for the largest total tonnage of fish caught. After indicating the weight of the largest fish of each species on a team's weigh-in slip, additional fish of any species may be combined to give a total weight of "all other fish" (Fig. 1). Though the total weight per year of the tournament would be accurate, the actual number of fish per species caught annually (Fig. 2) and catch per unit effort indices for species cannot be determined. The graphs do not include any of the fish listed under the "all other fish" category, and thus underestimate the number of fish caught. Still, the data from this tournament, plotted across a time series, may be useful in determining cyclical peaks in catch abundance of different species.

Unfortunately, there is no standard methodology for reporting tournament catch. While some tourna-



Figure 2. Number of each species caught annually at Tournament 10. Entries for both "marlin" and specific billfish were recorded throughout the tournament, even during the same year. The 2002 tournament was held in August, while all others were held in late October/early November.

ments simply report the species and weight of the fish, others include the area caught, the use of live/dead bait or lure, breaking strength of line, time of strike and capture or time fought, and the disposition of the fish. In addition, species classification may vary between tournaments, years, and weigh masters. Variation may even occur within a single catch report. For example, Tournament 10 records show that while specific billfish may be listed, they are often lumped under the general term of "marlin" (Fig. 2). This general term appears to be used concurrently with the species name because all billfish are included under a single prize category. Though this classification confounds the analysis of the data, the general trends of species abundance do not appear to be affected. The suggestion of a standardized catch report form, with input from this project, tournament organizers and clubs, has been positively received and will be a goal in the upcoming year.

While the tournaments give an annual snapshot of fishing activity, charter boat catches reflect an almost daily effort. We have obtained the daily charter boat weigh-in records from two small boat harbors and the HDAR annual charter boat catch statistics. These new additions to the database allow us to compare two aspects of the recreational fishery (charter boat and tournament) over different time intervals. Analyzing annual marlin catch of a tournament and charter boats weigh-in records using the same harbor reveals a similar trend in activity, with the exception of the 1996 blue marlin catch. A comparison of catch per unit effort indices as the weight of fish per boat per day between HDAR's charter boat catch and tournament catch does not yield consistent results. The reason for this discrepancy is not yet understood and will be the subject of future analysis. Additional comparisons between all sources of data may provide further insight into the pelagic recreational fishery of Hawaii.

Investigating the Life History and Ecology of Opah and Monchong in the North Pacific

P.I.: Michael P. Seki

Purpose of the Project

Two miscellaneous pelagics incidentally caught by longliners targeting bigeye tuna are the opah (*Lampris guttatus*) and monchong (*Taractichthys steindachneri* + *Eumegistus illustris*). Particularly valued by the restaurant trade in Hawaii, these exotic, deepwater fishes are generally harvested in small, but nevertheless significant, quantities. For the period 1987-99, as much as 300,000 lbs. of Amonchong were landed at United Fishing Agency (UFA) with individual fish averaging 14.2 to 17.7 lbs. Mean price ranged from \$1.35 to \$2.06 per lb. with annual ex-vessel revenue ranging from neglible (<\$10K) to \$420K. Over the same time period, 150,000 to 1.2 million lbs. of opah have been landed annually with individual fish weighing 97-111 lbs. Annual ex-vessel revenue for opah ranged from \$240K to \$1.4 million at a price per lb. ranging from \$0.87 to \$1.40. Since neither are targeted species, these fishes have historically been poorly studied and as a result available information pertaining to the biology and ecology of this resource are virtually nonexistent.

The primary purpose of this study is to investigate and define some of the fundamental life history and ecological characteristics of the opah and monchong resources in the North Pacific through a combination of comprehensive shoreside data and biological sample collection, analysis and merging of industry (NMFS observer and logbook, North Pacific driftnet, auction), research, and environmental datasets, and capture depth information collected from vessels of opportunity. Products from the study will include (1) comprehensive seasonal and where possible, interannual biometric summaries and relationships (e.g. length-weight, sex ratio, etc.), (2) determination of reproductive parameters (size and age at maturity, fecundity, spawning season, gonadosomatic index), and elucidate distribution patterns, preferred habitat, faunal associations, and trophic relationships for both Aspecific@ resources.

These results will provide fishery managers with new and much needed fundamental biological information that will help refine a precautionary reference point and provide insights into factors that enhance and reduce the incidental take of these species.

Progress During FY 2003

The project activities for both the opah and monchong resources fall under two major categorical subprojects: (1) a comprehensive shore-based biological sampling program designed to monitor landings and catch composition and to obtain the metrics (length, weight, sex) and samples (ovaries, otoliths, and stomachs) required for a comprehensive biological and ecological assessment and (2) an analysis of spatial distribution patterns, preferred habitat, faunal associations, and trophic relationships which involves the analysis and merging of industry, research, and environmental datasets, and capture depth information collected from vessels of opportunity.

Among the study highlights to date, it was fortunately discovered early that opah exhibit sexual dimorphism thereby enabling the determination of sex without having to cut into the body cavity to access the gonads; this determination has saved considerable time and energy, allowing substantially more data collection.

During efforts to estimate age-and-growth, preliminary examination of hard parts indicated that the second dorsal fin ray for opah and both sagittal otoliths and fin rays for monchong provide the best opportunity for aging these animals. As suspected, sagittal otoliths in opah are of vaterite form and are not conducive for daily increment enumeration. Assuming that annuli are formed annually, opah taken in the fishery are estimated between 1+ and 6+ years (i.e., 2 to 7 annuli) and the oldest monchong would be about 7 yrs. If microincrements (on postrostrum and/or rostrum of sagittal otolith) are daily, monchong appear to grow rapidly in the first year; ages of 42-49 cm fork length fish ranged from ~1 year - 13.5 months.

We've been particularly successful in obtaining capture depth information for both opah and monchong as well as biological samples on cooperative commercial longline fishing trips. On two trips, a total of 108 monchong and 34 opah were caught on 26 longline sets. Of these, 15 monchong and 1 opah were caught on the sections of longline instrumented with a series of time-depth-temperature recorders (TDRs) and hook timers. Additionally, another 7 opah (4 males, 3 females) were instrumented with Wildlife Computers popup satellite archival tags (PATS) upon capture and released.

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

P.I.: Benjamin Bolker

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 come from 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 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 2003

We have only been funded since January (a pre-award from the University of Florida was necessary to cover salaries for the first few months of the year). In that time, we prepared and submitted a manuscript to *Ecological* Applications ("Combining genetic and ecological data to estimate sea turtle origins," by Okuyama and Bolker) that details the first step of our grant: 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. While hierarchical Bayesian models are well described in the statistical literature, our paper gives a clear description of our particular method and of the general approach for ecologists. We then discuss a simulation scheme that generates random data sets given a series of parameters (the number of source populations, number of distinct haplotypes, sizes of rookeries, correlations between rookery size and contribution, range of contributions, etc.). We show that for sample sizes, numbers of rookeries and haplotypes, and variances in rookery size as observed in Atlantic sea turtle populations, the hierarchical Bayesian method often gives more accurate results. We then apply the model to Atlantic sea turtle data; the results do not suggest that previous analyses were generally correct, with the exception of some studies using small data sets. Importantly, the addition of ecological covariates is able to narrow confidence intervals sharply and to show statistically that some populations are definitely contributing to the mixed populations (where confidence intervals derived from non-hierarchical models were too broad to be able to make this conclusion).

Since submitting the paper, we made significant advances in the model selection problem, which is the next one we had set for ourselves. We determined that the *Deviance Information Criterion* (DIC), a metric recently developed by researchers in Bayesian statistics, has the desired properties of testing model fit while penalizing complexity.

(Simple rules such as the well-known Akaike Information Criterion are hard to apply to hierarchical models where the number of parameters is hard to define precisely.) Hierarchical models are essentially compromises between classical stock analysis models that contain a fixed contribution parameter for every source population and regression models that base the contribution for each source population solely on its ecological covariates, without allowing for any variation from the contribution predicted by the covariates. As such, their effective number of parameters is hard to estimate; the DIC provides a method. We implemented the DIC for our models and ran extensive tests both for our simulated sea turtle scenarios and for simpler "strategic" models to convince ourselves that the DIC really does reliably determine whether a model with or without ecological covariates gives more accurate answers under particular circumstances. We compared DIC with other, more traditional metrics such as the Bayes factor, and found that it works better for our applications: Bayes factors do not penalize additional model complexity sufficiently to determine the most accurate model. We are now finalizing our studies on this topic and preparing a manuscript.

Determination of the Habitat of Large Pelagics from Satellite Remote Sensing and Popup Archival Tagging

P.I.: Thomas Schroeder [Jeffrey Polovina]

Purpose of the Project

Describe the oceanic habitats (vertical and horizontal) for large pelagic fishes, sharks, and turtles using pop-up archival tags and satellite remotely sensed oceanographic data.

Progress During FY 2003

Deployed over 50 pop-up archival tags on various pelagics including bigeye tuna, opah, mako shark, whale shark, and albacore. Have begun analyses of the vertical and horizontal movement, depth, and temperature data from these tags.

A Sociological Baseline of Hawaii's Longline Fishery

P.I.: Stewart Allen

Purpose of the Project

National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Act of 1976 as amended in 1996 (MSA) requires analysis of the impact of proposed fishery regulations and similar activities on "fishing communities." NEPA analysis contained in Environmental Assessments (EA) and Environmental Impact Statements (EIS) requires a similar analysis of the impact of federal projects, including fishery regulations, protected species recovery actions and habitat designations on the human environment.

Unfortunately, the baseline for such analyses for Hawaii's longline fishery is quite slim, despite the intensity of interest directed towards that fishery sector. Previous socio-anthropological studies have emphasized the small boat fisheries of Hawaii and the traditional fisheries of American Samoa, Guam, and the Northern Mariana Islands. The recent EIS on the region's pelagic fisheries was required to utilize secondary data (e.g., Census maps and zip code information from permits) and information gleaned from economic studies to characterize the longline fishery. The socio-cultural portion of that EIS was forced to use the entire State of Hawaii as the unit of analysis for social impacts and to define the entire Honolulu area as a "fishing community" even though more discrete social and geographical units might have been more appropriate.

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. The longline industry has been heavily regulated with little understanding of the sociocultural impacts of those regulations and management. Project researchers intend to address this problem directly by: compiling a comprehensive social profile of the longline fishing industry of Hawaii; and providing social profile information to decisionmakers on regulatory impacts and implementation strategies.

Project researchers are conducting direct in-person interviews and, as needed, focus groups with longline captains, owners, crews, and family members, as well as key individuals in associated shoreside businesses (including the auction, fishing supply and support industries, wholesale and retail seafood dealers.) The purpose is to compile a demographic profile and network analysis of economic and social interactions which would enrich subsequent NEPA analyses.

Deliverables will include a database of responses from the Hawaii longline fishing community, and a report summarizing those data and providing contextual information for evaluating those data. Although some of these data will be confidential due to the sensitivity and potentially statutorily confidential nature of these responses, a research database to be shared with other researchers will be constructed as well. These deliverables, to be updated on a regular basis, will constitute the baseline for subsequent NEPA analyses.

Progress During FY 2003

Approval from the University's Committee on Human Studies was obtained for the research, which was granted an exemption from Department of Health and Human Services regulations. The required Informed Consent form was developed for interviewees to sign. Research Assistant Amy Gough was hired on January 6, 2003 to help refine the project and conduct field interviews.

To date, an interview schedule has been developed and refined, and interviews have been conducted with 13 individuals, primarily Vietnamese owners and/or captains of longline boats. We focused on this component of the industry for two reasons. First, we already had hired an excellent Vietnamese interpreter to assist with a brief federal study of family impacts associated with the closure of the swordfish fishery. Second, the interviews are being coordinated with a federal study of the cost-earnings patterns associated with the Hawaii longline fishery that is collecting information from a number of Vietnamese boat owners.

Scheduling interviews with boat owners and captains has proved to be challenging given their schedules. Previous similar efforts have attempted to contact individuals opportunistically at the docks, but this is not practical when an interpreter/translator needs to be present. So far people have been willing (and sometimes eager) to talk about longline fishing; no one has refused to be interviewed when asked. Having the Vietnamese interpreter set up the interviews has been helpful in this regard, as well as promoting responses during the interviews.

Because the study is ethnographic research, not a survey, there is no questionnaire. The interview schedule is a highly flexible document that covers a broad range of topics; in practice, no interviewee is asked the same set of questions. Instead, the focus is on getting people to address social and cultural aspects of longline fishing and the meaning of those characteristics to their lifestyles. In addition, different approaches to the interview will be used for different sectors of the industry. With this in mind, here are the topics intended to be covered during the interviews:

History in the fishing industry, how they got started in it, and how they became involved with the Hawaii-based longline industry.

Current job in the longline industry and what they like most and least about it.

Job satisfaction and perceptions of whether they made a reasonable income from the longline industry in 2002 compared to previous years.

Obstacles faced in the longline industry, how they responded, what options they considered in addressing the obstacles, and perceptions of their decision.

Future plans for involvement in the longline industry in Hawaii and perceptions of its viability.

Level of information they have regarding fishing regulations and management, where they get information, and perceptions of the adequacy and accuracy of that information.

Personal involvement in management issues affecting the longline industry and suggestions for fishery managers.

Evaluation of the effectiveness and efficiency of longline fishing regulations and how they and their families have been affected.

Social networks they or members of their households are a part of, both within and outside the longline industry. Perceptions of these social networks and their benefits.

Perceptions of quality of life, their community, attachment to place, and whether they live in a fishing community.

Demographic characteristics such as household size and composition, proportion of household income from fishing, work experience or training outside the fishing or longline industries, environmental orientation, and ethnicity.

The opportunity to say anything else you want to say about themselves, their role in the longline industry, social networks, or fishing in general.

Whether they would like to see a copy of the results of the study when completed.

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, Richard Brill, Christofer Boggs, Marti McCracken, Randall Arauz

Purpose of the Project

The objective of the proposed research is to determine the efficacy of a bait or gear modification that could significantly reduce the incidental capture of marine turtles in longline fishing gear. In addition, with the use of pop-up satellite archival tags, the research will also refine estimates of sea turtle survivorship post-capture and release from longline fishing gear.

Progress During FY 2003

Permitting Problems

This project has been delayed due to the lengthy process of acquiring necessary permits required for US and Costa Rican scientists to pursue this research that may impact threatened species. C. Boggs is leading the process to obtain US-based permits with NMFS headquarters in Silver Spring, MD. A summary of the current issues are mentioned below:

This grant has been set up such that the project's PI (John Sibert) has issued a subcontract from JIMAR PFRP to TIRN to conduct the research. This subcontract is funded by Cooperative Agreement Number NA67RJ0154 from NOAA. TIRN is a California incorporated non-profit (501 c 3). One potential option that would enable us to progress with the proposed research might be to cancel the subcontract with TIRN and instead issue a subcontract to Randal Arauz's Costa Rican non-governmental organization (PRETOMA).

The argument has been made that turtles taken in the planned research would be those that are caught incidental to this fishery, and thus this research would incur no directed take of turtles. If this were an issue for a Section 10 Permit, however, the work could all be done inside the EEZ. All of the work will be conducted onboard Costa Rica-flag fishing vessels. All the at-sea work could be conducted by citizens of Costa Rica, although TIRN would like to let US students help with the work if that wouldn't affect the status with regard to needing a Section 10 permit.

All of the appropriate permissions for the work are being obtained from the Government of Costa Rica by R. Arauz. None of the sea-going participants will be officials or employees of the Costa Rican government. Collaborating scientists on the research project include R. Brill and Y. Swimmer. These collaborators are named in the permissions being provided by the Costa Rican government. These NMFS employees will not be directly involved in capturing turtles and do not need to go to sea on the vessels that conduct the work.

At this point, NMFS headquarters will review our requests and discuss possibilities with Endangered Species Act officials. Because the source of these funds are Federal, and due to participation by Federal employees in the research, it has been suggested that a Section 7 consultation and a Section 10 permit would be required. However, due to a precedent set by Alan Bolten to conduct similar studies in the Azores without any such permits, this research may be exempt from these requirements. Another potential obstacle, however, is the potential NEPA requirements. We await to hear from NMFS headquarters on all these matters.

Study Design Progress

In spite of this delay, we have pursued planning for this research and are fully prepared to conduct studies once we have the necessary permits. Accomplishments to date include a study design that will allow for the greatest statistical power. Specifically, Marti McCracken has taken the lead in identifying critical factors necessary to ensure successful analysis of our data.

1) Assignment of Bait. For the experiment comparing blue dyed and untreated squid, Marti suggests that the same treatment (blue dyed or untreated bait) be used throughout the set and that treatments be randomly assigned to

the set. For other treatments, such as different types of hooks, this would not be the case, as in these situations, we may want to have a set contain the different treatments as there are advantages (e.g., to control for some of the environmental variables). Additionally, the study design would not include the same treatment to all sets within a trip (or vessels), as this would prevent an estimation of the variation between trips (vessels).

- 2) Controlling variables that may influence the catch rate. If possible the number of hooks between sets and any other variable that may influence the catch rate of turtles or the target species will be held constant. For example, all sets should have the same number of hooks with approximately the same distance between hooks, and they should be approximately at the same depth. If it is not possible to control these variables, they should be recorded.
- 3) Number of vessels. If we have vessels doing multiple trips the factors in our anova will be (1) vessel, (2) trip within vessel, (3) and treatment (there may be covariates as well). The set within a trip is our replication. If each vessel does only one trip, the factors in our anova will be (1) vessel and trip (these two factors are confounded) and (2) treatment. Hence, if vessels are going to do multiple trips and there is more than one vessel, then all vessels should do the same number of trips. If there is only one vessel, we do not have the problem of variation between vessels, but the experiment would be drawn out over a longer period. If each vessel only does one trip, then the vessel and trip effect are confounded, but this is not too concerning since the objective is to test the effect of the treatment.
- 4) To obtain a balance design, each trip needs to do the same number of sets and each treatment needs to be equally represented within a trip. This may not be practical, but if each vessel agrees to do a minimal number of sets during a trip, say eight, then we would just use the first eight sets. Before the trip departed, we could randomly assign the treated bait to four or the first eight sets.
- 5) Determining the number of sets needed. Because the treatment is being randomly assigned to the set and not the hook, the set is our experimental unit. If at all possible, the number of hooks on a set should be held constant throughout the experiment. If this is not possible, then the number of hooks in a set will be a covariate in the anova and estimating the number of sets needed for a desired result becomes more complicated. We will not assume that turtle catch has a linear relationship with the number of hooks as the number of turtles that encounter the longline is not a factor in our control. Although the bycatch rate is high in the Costa Rica fishery, the fact that the rate of one turtle for 180 hooks suggest that a limited number of turtles may encounter the longline.

To calculate the sample size, we need to formalize how we are going to quantify the success of the treated bait. This will likely be an estimate (including a confidence interval) of the difference between the two treatments. If there is a reduction of turtle bycatch with the treated bait, then this reduction is estimated. In order to calculate sample size, we will need an estimate of the variation in bycatch between sets.

Furthermore, in order to determine the impact of treated baits on catch rates of mahimahi, we will either do a one-way (reduction in catch) or a two-way test (reduction or increase in catch). Once again, a measure of the variation in the mahimahi catch between sets is needed in order to determine sample size.

The Role of Oceanography in Aggregation and Vulnerability of Bigeye Tuna in the Hawaii Longline Fishery from Satellite, Moored and Shipboard Time Series

P.I.: Russell E. Brainard, Jeffrey J. Polovina, Michael P. Seki, Patrick Hyder, Bo Qui, and Pierre Flament

Purpose of the Project

Stock assessment of Bigeye tuna is generally based on longline catch-per-unit-effort (CPUE) as an index of abundance. Unfortunately, fishery-dependant CPUE does not necessarily reflect abundance of stock, but the catchability which is dependant on variable oceanographic conditions. Preferential foraging habitat appears to be the 8-15°C waters near the base of the thermocline so variability of thermocline depth could affect concentration. Away from floating objects Bigeye tuna tend to remain in the upper 10-90m at night and repetitively during the day, migrating vertically between 350-500m and between 50-150m (where there blood temperature increases in warmer waters after diving). A recent paper in the southern Pacific by Shaefer and Fuller (2002) suggests on rare occasions to escape predation the fish can exceed 1000m in depth.

In November 2002, Pat Hyder joined the project. Two years mooring data were already collected at a site in the Hawaiian Lee region at 20°36'N, 161°34'W and 13 years Hawaiian long line fish, catch and CPUE data (filtered to include deep sets of >10 hooks between floats) were made available. The mooring was redeployed for a third year in August 2003. Through comparison with satellite derived AVISO sea surface height data, the mooring data facilitates analysis of the oceanography of the Hawaiian Lee region which is characterized by extreme mesoscale variability which masks the mean circulation (Lumpkin and Flament, 2000). We aim to gain insight into CPUE variations associ-



Lateral sonar for 3D images of schools, vertical sounder for density estimates, long-range sonar for remote observations of school movements and positions.

ated with these mesoscale features. Various satellite imagery and numerical model data will be used to compliment the mooring data and investigate how these and larger scale and longer term variations in the ocean environment effect catchability (CPUE). A comparison with other regions and species will increase our understanding of the accuracy of CPUE as an indicator of abundance.

Progress During FY 2003



Figure 1. The bi-monthly variation in the latitudinal distribution of effort (hooks), catch (fish) and CPUE for the Hawaiian long line fishery together with the upper layer temperature (from the JPL ECCO model). The known surface water preference range (23- $26^{\circ}C$) for each of the bimonthly periods is marked with stars. The color code for bimonthly depth is Jan/Feb (red), Mar/Apr (green), May/ Jun (blue), Jul/Aug (yellow), Sep/Oct (Cyan), Nov/Dec (Magenta). Note the contrast between the southern location of the maximum CPUE in March/Apr (green) when preferred thermal range is further south, and the southern location of the maximum CPUE in Sep/Oct (cyan) when preferred thermal range in furthest north.

CPUE Data Analysis

The Hawaiian long line fishery data for deep set lines (> 10)HBF) suggest abundance varies on a variety of length and timescales from inter-annual variations associated with abundance and fishing levels; to seasonal variations associated with annual migration; and on to mesoscale and short term variations associated with mesoscale features and short term fluctuations in the ocean. Fishing effort for Bigeye tuna in Hawaiian waters has increased steadily over the last decade resulting in a steady increase in catch. The annual mean CPUE increased from 1990 until 1998 (an ENSO year), after which the catch appears to reduce despite increased effort. Long-term monthly averages close to Hawaii reveal a clear seasonal cycle with a maximum CPUE during winter more than five times the minimum CPUE during late summer. The effort also reduces during the summer period (although only by ~50%) as the result of boats switching target species. This seasonal trend in both catch and effort in Hawaiian waters is indicated by Curran (1996) for several pelagic species such as Albacore, Bluefin, Swordfish, Striped Marlin (whilst Black Marlin and Mahi-mahi apparently have maximum catches during winter, and Yellowfin Tuna and Blue Marlin appear to have less seasonal variation).

Seasonal ocean temperature variations are particularly pronounced in sub-tropical waters where water temperatures can vary annually by as much as 17°C (13 to 30°C). These annual cycles could potentially concentrate Bigeye tuna (and other pelagic fish) in low latitudes in the respective winters since the fish are known to have a preference for surface waters between 22 and 26°C to warm up between dives. Conversely, during the late summer fish might be expected to migrate north when the surface waters are warmer.

Latitudinal variations in effort, catch and CPUE over the annual cycle have been averaged in bimonthly blocks over the 13 year period and compared with averaged surface temperatures from the JPL ECCO model (Figure 1). The maximum CPUE regions are further



Figure 2. The annual migration of the center of mass of effort (hooks), catch (fish) and CPUE calculated seasonally over the thirteen year period (1990-2003). The centre of mass is defined as the sum of parameter multiplied by latitude divided by the sum of parameter and hence represents a weighted mean latitude. Note its maximum northern extent in late summer (0.7) and maximum southern extent in late winter (0.2 to 0.5).

north in the third quarter when surface waters in the sub-tropics reach their maximum temperature and furthest south in the first quarter when surface water temperatures in the sub-tropics fall below the preferred thermal range (and might be expected to concentrate fish in tropical waters). The figure appears to indicate a north-south annual migration primarily driven by the preferred surface water temperature range of 23 to 26°C, but also suggested the CPUE distribution could be influenced by preferential spawning (close to Palmyra) and feeding grounds (such as the sub-tropical convergence front at ~ 30 N). It should be noted that the upper limit of preferred thermal range is probably not critical since fish could find the desired thermal range by resting lower slightly lower in the water column. This suggested migration appears to be confirmed by the motion of the centre of mass of the CPUE of the Hawaiian fishery which also indicates seasonal north-south migration (Figure 2). It should be noted that this type of migrations could also result from a habitual or trophic-related migration (and hence may not be thermally driven).

Preliminary analysis of the long line data for the whole Pacific (from Secretariat of the Pacific) shows broad agreement with analysis of the Hawaiian longline data. In particular, the annual migration appears to be evident for Bigeye throughout the Pacific. In addition, the bimonthly latitudinal CPUE variation and seasonal variations in the centre of mass appear to suggest varying seasonal cycles in both latitudinal and longitudinal CPUE distribution for several species (albacore, swordfish,

marlin and tuna) and which could result from annual east-west and north-south elliptical migrations. Further work including comparison between species is required to determine to what extent the CPUE variations reflect true variations in the abundance of fish or simply reflect variations in effort type or catchability.

A preliminary analysis of mesoscale variations in catch in the Hawaiian Lee region has been undertaken using AVISO data. This shows very high catch and CPUE locations are frequently associated with mesoscale features. However, since variability is extensive further analysis is required to determine which type of feature high or low catches are associated with. The Hawaiian long line data also indicate a noticeable decrease in the annual mean CPUE after high catches in Palmyra associated with upwelling in January 1998 (during the 1997-98 ENSO).

A detailed study has been undertaken on catches in relation to oceanographic conditions close to Palmyra (158-167°W, 0-10°N). Extremely high catches in early 1998 are associated with periods of elevated thermocline during the winter months. It is thought that these variations could result from short term eastward horizontal advection of mid-to higher level trophic organisms in mesoscale features which form around Palmyra Atoll during fluctuations in the equatorial current. Further work is required to investigate exactly how CPUE varies with oceanographic conditions in these tropical waters.

Oceanographic observations

The thermal structure at the mooring (Figure 3) indicates mesoscale variations and a strong internal tide. The mooring data have been provided to University of Hawaii investigators (HOME project) to examine the dynamics of internal tides. The thermocline is predominantly at its deeper level of around 175m during most of the year but it elevated to around 120m for short periods during winter 2000 (Day 344) and longer periods of around 100 days during June to July in both early summers (Day 170 & 530) and October to November in both autumns (Day 280 & 650). Inspection of sea surface height, SSH, imagery (AVISO) suggests the observed variations are associ-



Figure 3. The vertical thermal structure observed at the mooring location during both deployments (December 1999 to December 2001).

ated with the passage of cyclonic eddies across the mooring location. There is a reasonable correlation between dynamic height at the mooring and SSH given the lack of upper layer temperature data due to instrument failure. Long term sea-surface height variations in AVISO suggest there could be seasonal changes in the generation of eddies in the Hawaiian Lee region which could be associated with seasonal variations in the wind field. Wind shear associated with the Hawaiian Island wake is known to be important both in the generation of eddies and forcing the mean residual circulation. Hence seasonal variations in wind strength and direction could be expected to influence eddy kinetic energy and mean flow. However, since variations in the time of eddy occurrence between years of similar time scales to the eddy duration mask the seasonality in the mean annual cycle further work is required to investigate this.

SSH (AVISO) data indicates the formation and westward propagation of cyclonic and anti-cyclonic eddies in the Hawaiian Lee region. It also suggests the mooring location is close to the border between the predominantly cyclonic and predominantly anti-cyclonic regions (Lumpkin and Flament, 2000) and the location of mean eastward flow associated with the Hawaiian Lee countercurrent. We aim to try to characterize the seasonal variation of eddy energy at the mooring site over the two years and compare them with seasonal wind seasonal variations. These variations will also be compared with AVISO data at the mooring location over the same period and used to interpolate the analysis spatially over the Hawaiian Lee region. It should be noted, however, that since the uncertainty in location of the CPUE data (~50 km), resulting from the length of the lines, is of the same order of the eddy scale it is impossible to investigate the effects of sheer or fish concentration by pycnocline depth using this data.

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

P.I.: Pierre Kleiber, Hideki Nakano, John Sibert Co-P.I.: John Hampton

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 2003

During FY 2003, this PFRP project joined forces with a non-PFRP project that has similar aims with regard to habitat-based effort standardization, but a target species of bigeye tuna rather than blue sharks. The bigeye project is conducted by K. Bigelow of NFMS and J. Hampton of the Secretariat of the Pacific community. The computer specialist funded by this PFRP project, V. Khurana, has worked on database applications applicable to both projects. He has implemented a way to access fishery data held on Oracle databases directly from the statistical and graphics program, R. He has also developed an application in which an arbitrary geographical mosaic can be conveniently specified, and fishery catch, effort, and size data are then aggregated into that mosaic in preparation for input to the stock assessment program, MULTIFAN-CL.

A workshop on longline effort standardization sponsored by this project in FY 2002 spawned two informal datagathering efforts both outside the work originally envisioned for this project but nevertheless highly relevant to it. One of these has been assembling data for a Pacific-wide assessment of striped marlin. The data include catch, effort, and size sample data from most fisheries that catch striped marlin in the Pacific. Tagging data are also included. The data are almost complete as of this writing, awaiting keypunching of Mexican fishery data and receipt of Japanese size sample data.

The other data-gathering effort spawned by the workshop is an attempt to assemble from various agencies information bearing on the depths at which longline caught fish are habitually hooked. The data are to include hook timer and time-depth recorder data from experimental or commercial longline sets, plus data from longline observer programs in which positions of hooked fish relative to floats are noted. Information from P. Bach of the Institut Recherche pour le Developpement in Tahiti has been received so far, and another French scientist, F. Poisson is presently working for a time at the NMFS Honolulu Lab in part to examine and organize a backlog of hook timer and time-depth recorded data held there. It is hoped that extensive similar data collected by Japanese scientists can also be included.

The plan for FY 2003 to work up longline shoaling indices from oceanographic data provided by the Oceanic Atlases project has been postponed to the following year to allow time for the PI (P. Kleiber) to work on a project to develop and document MULTIFAN-CL. While this task is not specifically funded by this PFRP project, it is still very relevant that MULTIFAN-CL is the principal assessment tool which will be used to analyse standardized longline effort and associated other fishery data.

Modeling Longline Effort Dynamics and Protected Species Interaction

P.I.: PingSun Leung, Naresh Pradhan, and Sam Pooley Collaborator: Omar El-Gayar

Purpose of the Project

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

- (1) Extend the longline trip level time-series data set to 2002.
- (2) Re-estimate the technical and economic interrelationships among different species landed and the entry/stay/ exit behavior.
- (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 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 2003

The project started on January 1, 2003 when funding became available. Most of the project work during the last three months has been related to getting the project off the ground and acquiring the extended data set for the years 1999-2002 of the longline fleet. The following summarizes the major activities:

- (1) A research assistant has been hired and will begin on May 19, 2003.
- (2) Two papers from the previous project (which has led into this current project) have been finalized and ac cepted for publication.
- (3) Two papers have been drafted and sent to journals for publication consideration. Both papers are based on previous project work using data up to only 1998. One paper is on longline trip choice modeling and the other one is on longline fishers' entry, stay, and exit behavior.
- (4) Met with NMFS modeling group (Sam Pooley, Mingling Pan and Keiichi Nemoto) discussing the possible areas of improvement of the present fleet dynamic allocation model and possible avenues for cooperating in the overall modeling effort.
- (5) Discussed with NMFS group on the possibility of combining the data preparation effort in order to have a consistent set of data for all concerns.
- (6) Made necessary arrangement in obtaining the observer data set.
- (7) Reviewed literature on modeling protected species interaction and a preliminary review of literatures on modeling catch-effort relationships.

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.

Coral Reef Management Initiative

P.I.: Alan Everson, John Naughton

Purpose of the Project

The goal of Coral Reef Management Initiative (CRMI) is to establish an enhanced coral reef management presence within the existing NMFS, Pacific Islands Area Office (PIAO), Habitat Conservation Program (HCP). The CRMI relates directly to the JIMAR Coastal Research theme of achieving sustainable balance between the forces of coastal development and preservation. Information obtained as a result of CRMI 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 appropri-



Bleached pocilloporid corals in the central lagoon of Kure Atoll, September 2002.

ate 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.

Progress During FY 2003

A number of field assessments have been conducted at Guam, Rota, Kwajalein, American Samoa, and in the Hawaiian Islands related to inventorying resources and/or assessing post-development recovery and mitigation success, and have resulted in a number of reports. A mitigation database was created to assess various mitigation techniques examined and/or described in the literature, with progress on transplantation methods being made to date for ultimate guideline development. We helped establish and co-chair an interagency coral reef mitigation working group involving Federal and State government representatives for the purpose of streamlining and standardizing mitigation review. We recently proposed and held a two-day workshop on field assessment for mitigation endeavors with roughly 60 coral reef scientists and managers in attendance. A number of presentations have been made at local and international venues related to our focused attempts with regards to adequately assessing and implementing compensatory mitigation for damages to coral reef areas.



Marine Debris Removal Team and their cumulative 86 tons of marine debris, Midway, July 2003.

Sustaining Healthy Coastal Ecosystems

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

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 assisting in 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 to conserve coral reef resources of the US Pacific Islands.

Progress During FY 2003

During 2002-2003, the Sustaining Healthy Coastal Ecosystems program conducted multi-disciplinary research cruises to conduct baseline assessments of the fish, corals, other invertebrates, and algae of the coral reef ecosystems of the Northwestern Hawaiian Islands (NWHI), the Territory of American Samoa, and the remote US Line and Phoenix Islands, Guam, and the Commonwealth of the Northern Mariana Islands. These research cruises also conducted benthic habitat mapping activities consisting of towed diver, towed camera, and acoustic classification surveys. Some interesting results have already emerged from ongoing fish surveys and data analysis in the US Pacific Islands. In February 2002, nine years after a major ship grounding occurred at Rose Atoll, American Samoa, fish surveys found that both numerical and biomass densities of pooled herbivores (surgeonfish, parrotfish, and angelfish families) were several-fold greater at the wreck site than elsewhere around the atoll in 2002. 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 at the site. 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 fish, or target species (e.g., grouper) 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, 2003 fish monitoring continued to document high abundance of top-level predators (mainly jacks and sharks), following completion of baseline assessments in previous years.

On the August/September 2002 cruise, scientists documented widespread coral bleaching affecting the shallow reefs (<60' depth) of the Northwestern Hawaiian Islands (NWHI); reefs at the three most northern atolls (Pearl & Hermes Atoll, Midway Atoll, and Kure Atoll) were the most severely affected. Coral bleaching, triggered by a combination of elevated sea surface temperature and UV radiation, has been linked to the larger phenomenon of global warming, and reports of bleaching on tropical reefs throughout the world have become increasingly common over the past decade. This is the first time that mass coral bleaching has been observed in the NWHI, an area that some scientists had speculated would be relatively immune to bleaching due to its sub-tropical latitudes. In response to this bleaching event, 5 scientists from NMFS, US Fish and Wildlife Service, and HDAR traveled to Midway Atoll in December 2002, to re-survey the affected reefs. Some affected species of corals appeared to be recovering, while other species showed partial mortality and algal overgrowth. Further surveys on upcoming cruises to be conducted throughout the NWHI in FY 2003 will enable scientists to better understand the short-term aftermath of this wide-spread bleaching episode, and its effect on longer-term ecological change.

Additionally, in-situ oceanographic observations were conducted consisting of shipboard CTDs and ADCP transects, as well as closely spaced shallow water CTDs over the reef slopes from small boats. To date, over twenty-one oceanographic moorings of four types have been deployed to establish high-resolution time series observations of key parameters influencing reef health. These systems include 15 surface systems which utilize the Argos global data telemetry and geo-positioning satellite system to deliver data in near real-time to the Pacific Islands Fisheries Science

Center and the Coral Reef Early Warning System (CREWS) data analysis center in Miami, FL. Subsurface systems (without telemetry) measuring ocean currents and waves energy have also been deployed. Three SVP drifters have been deployed in the subtropical pacific convergence zone to study potential patterns of marine debris circulation. During FY 2003 (summer), 14 surface velocity program (SVP) satellite-tracked drifting buoys are being deployed in the NWHI, Guam, and CNMI. Five SVP drifters are being deployed in the vicinity of American Samoa to examine ocean circulation patterns influencing larval transport and recruitment dynamics.

This program also assists the large-scale multiagency effort to remove derelict fishing gear from the reefs and beaches of the NWHI. Over 230 tons of marine debris had been removed from the NWHI through 2002. Current year (FY 2003) operations are underway with two chartered vessels, 16 divers, and



JIMAR employees Kim Page and Peter Vroom monitoring cover of tropical reef algae at Pearl and Hermes Reef, Northwestern Hawaiian Islands.

a field season than runs from May-September. The effort this year is focused on Pearl & Hermes Atoll and Midway Atoll. To date, over 86 tons of marine debris had been removed in 2003. This program also conducted numerous outreach and education activities to better inform industry and the public aboard the problems of marine debris in the ocean environment. A research project to identify sources of debris has been undertaken.

An investigation to study the role of oceanographic phenomenon on bigeye tuna aggregation and vulnerability in the Hawaii longline fishery, undertaken in Dec 1999, has collected data from satellites, shipboard time series, and a deep ocean mooring of ocean properties including water velocity, temperature, salinity, dissolved nutrients, and oxygen content. The deep ocean mooring, known as the Bigeye mooring, has just been deployed for the third year.

Names of Students Graduating with MS or PhD Degrees during FY 2003

Jon Winsley, MS, Ocean Resources Engineering, SOEST, University of Hawaii.

Marc Lammers, Ph.D., SOEST, University of Hawaii. June, 2003. The broadband acoustic signaling behavior of Hawaiian spinner dolphins (*Stenella logirostris*).

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Appendices

Appendix I. List of Acronyms

Appendix II. Visiting Scientists

Appendix III. Seminar List

Appendix IV. Workshops and Meetings Hosted by JIMAR

Appendix V. JIMAR Organization

Appendix VI. JIMAR Personnel

Appendix I: LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profiler
ADP	Acoustic Doppler Profiler
ADRM	Advection-Diffusion-Reaction Model
AGCM	Atmospheric General Circulation Model
ANOSIM	Analyses of Similarities
APDRC	Asia-Pacific Data-Research Center
ARSHSL	Archive of Rapidly-Sampled Hawaiian Sea Level
BPUE	Bycatch Per Unit Effort
cDNA	Cloned Deoxyribonucleic Acid
CDP	Climate Data Portal
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CLIVAR	Climate Variability and Predictability Program
CNMI	Commonwealth of the Northern Marianas
CPC	Climate Prediction Center
CPUE	Catch Per Unit of Effort
CRE FMP	Coral Reef Ecosystems Fishing Management Plan
CREWS	Coral Reef Early Warning System
CRMI	Coral Reef Management Initiative
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity Temperature Depth
DAC	Data Assembly Center
DHNM	Directoria de Hidrografia e Navegacao da Marinha (Brazil)
DIAS	Document Imaging Archival System
DIC	Deviance Information Criterion
DNA	Deoxyribonucleic Acid
DSS	Data Server System
EASM	East Asian Summer Monsoon
ECHAM	European Center-Hamburg Atmospheric Model
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ELISA	Enzyme-linked Immunosorbant Assay
ENSO	El Niño/Southern Oscillation
EOFs	Emperical Orthogonal Functions
EPIC	East Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System
EPO	Eastern Pacific Ocean
ERS	European Remote Sensing Satellite
ESA	Endangered Species Act
FADS	Fish Aggregation Devices
FY	Fiscal Year
GAM	Generalized Additive Model
GAMS	General Algebraic Modeling System
GASEX-II	Gas Exchange Experiment II
GCM	Global Circulation Model
GEOSAT	U.S. Navy GEOdetic SATellite

GFDL	Geophysical Fluid Dynamics Laboratory
GIS	Global Ionospheric Studies
GLOBEC	Global Ocean Ecosystem Dynamics
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GPS	Global Positioning System
GPS@TG	Global Positioning System at Tide Guage Stations
GTSPP	Global Temperature-Salinity Profile Program
HCP	Habitat Conservation Program
HDAR	Hawaii Division of Aquatic Resources
HIBT	Hawaii International Billfish Tournament
HIMB	Hawaii Institute of Marine Biology
HL	Honolulu Lab
HMS	Highly Migratory Species
HOTS	Hawaiian Ocean Time Series
HRCWN	Hawaii Regional Coast Watch Node
HSCO	Hawaii State Climate Office
HSLC	Hawaii Sea Level Center
HTTP	Hawaii Regional Tuna Tagging Project
IAPSO	International Association for the Physical Sciences of the Ocean
IATTC	Inter-American Tropical Tuna Commission
IHO	International Hidrographic Organization
IOOS	Integrated Ocean Observing System
IPRC	International Pacific Research Center
IRI	International Research Institute for Climate Prediction
ITCZ	Intertropical Convergence Zone
JASADCP	Joint Archive for Shipboard Acoustic Doppler Current Profiler
JASL	Joint Archive for Sea Level
JASMINE	Joint Air-Sea Monsoon Interaction Experiment
JASON	Name of a satellite (http://topex-www.jpl.nasa.gov/mission/jason-1.html)
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JI	Joint Institute
JIMAR	Joint Institute for Marine & Atmospheric Research
KRF	Kewalo Research Facility
MARDAP	Marine Resource Dynamics and Assessment Program
MFSE	Medical Foundation for the Study of the Environment
MMPA	Marine Mammal Protection Act
MPI	Maximum Potential Intensity
MRFSS	Marine Recreational Fisheries Statistical Survey
NAO	North Atlantic Oscillation
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environmental Predictions
NEC	North Equatorial Current
NEPA	National Environmental Policy Act
NetCFD	Network Common Data Format

NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NOSA	NOAA Observing Systems Architecture
NVODS	National Virtual Ocean Data System
NWHI	Northwest Hawaiian Islands
NWS	National Weather Service
NWSPR	National Weather Service Pacific Region
OACES	Ocean-Atmosphere Carbon Exchange Study now called GCC (Global Carbon Cycle
OGCM	Ocean General Circulation Model
OGP	Office of Global Programs
OpeNDAP	Open Source Project for a Network Data Access Protocol
PACS	Pan American Climate Studies
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	Principle Investigator
PIAO	Pacific Islands Area Office
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
PMEL	Pacific Marine Environmental Laboratory
PNA	Pacific North America
POFI	Pelagic Fisheries Oceanic Investigations
POM	Princeton Ocean Model
POM	Particulate Organic Matter
PRT	Program Review Team
PSATs	Pop-up Satellite Archival Tags
PTT	Platform Terminal Transmitter
PV	Potential Vorticity
PVU	Potential Vorticity Unit
PW	Precipitable Water
RAM	Regional Atmospheric Model
RCM-9	Recording Current Meter 9
RFP	Request for Proposals
SCTB	Standing Committee on Tuna and Billfish
SELF	Synoptic Eddy and Low-frequency Flow
SIO	South Indian Ocean
SLH	Sea Level Height
SLP-Pac	Sea Level Project in the Pacific
SOC	Specialized Oceanographic Center
SOEST	School of Ocean and Earth Science and Technology

South Pacific Commission
Senior Research Council
Sea Surface Height
Sea Surface Temperature
Stenella Abundance Research Project
Surface Velocity Program
Thermal Array for the Ocean
Temperature Depth Recorders
Tropical Ocean-Global Atmosphere
Topographic Experiment (NASA)
United Fishing Agency
University of Hawaii
University of Hawaii Sea Level Center
University of Guam
United States
U.Saffiliated Pacific Islands
United States Geological Survey
Visual FoxPro
World Meteorological Organization
Western North Pacific
World Ocean Climate Experiment
Western Pacific Fishery Information Network
Western Pacific Regional Fishery Management Council
Zenith Neutral Delay

Appendix II: VISITING SCIENTISTS

July 1, 2002 to June 30, 2003

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
07/16/02 - 07/28/02	Dr. Tri Duong Long Fisheries Information Centre Hanoi, Vietnam	Collaborate with PFRP scientists and attend 15th Annual Standing Committee on Tuna and Billfish Meeting
07/17/02-07/26/02	Dr. Felipe Galvan-Magana Centro Interdisciplinario De Ciencias Marianas Fisheries	Collaborate with PFRP scientists and attend 15th Annual Standing Committee on Tuna and Billfish Meeting
07/20/02-08/03/02	Sri Dyah Retnowati Directorate General of Capture Fishery, Indonesia	Collaborate with PFRP scientists and attend 15th Annual Standing Committee on Tuna and Billfish Meeting
07/20/02 - 08/17/02	Dr. Noel Barut Phillippine Government National Fisheries	Collaborate with PFRP scientists and attend 15th Annual Standing Committee on Tuna and Billfish Meeting
07/22/02-08/06/02	Dr. Erwan Josse I R D, Plouzane France	Collaborate with Dr. Kim Holland and other JIMAR scientists and work on various aspects of Pelagic Ecosystem research
07/24/02 - 07/31/02	Dr. T. N. Krishnamurti Florida State University Dept. of Meteorology	Collaborate with Dr. Bin Wang and other JIMAR scientists Dept. of Meteorology professors
09/05/02-09/17/02	Dr. Charles Magori Kenya Fisheries	Collaborate with Dr. Mark Merrifield and other UHSLC regarding sea-level data collection, analysis and interpretation
09/08/02 - 10/07/02	Dr. Peter Vroom University of Hawaii	Collaborate with NMFS researchers and conduct rapid ecological assessments, benthic habitat mapping and long term biological and oceanographic monitoring of Coral Reef ecosystems
09/27/02 - 10/03/02	Dr. Peter Holloway Australian Defence Force Academy	Collaborate with Dr. Mark Merrifield of the University of Hawaii Sea Level Center regarding Hawaii Ocean Mixing Experiment (HOME) and other UHSLC researchers
10/07/02 - 10/13/02	Dr. Carlos Robinson Mexico City, Mexico	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/07/02 - 10/12/02	Dr. William C. Burgess Greenridge Sciences Inc Goleta, CA	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/06/02 - 11/10/02	Dr. John Simmonds FRS Marine Laboratory Aberdeen Scotland	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/02/02 - 10/12/02	Dr. Patrice Brehmer Centre de Recherche Halieutique Sete Cedex France	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregations Behavior of Pelagic Fish Workshop
10/04/02 - 10/11/02	Dr. Marc Soria Institut de Recherche Pour le Development(IRD) Universite de la Reunion	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregations Behavior of Pelagic Fish Workshop

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
10/04/02 - 10/19/02	Dr. Rene Vabo Institute of Marine Research Bergen, Norway	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/06/02 - 10/12/02	Dr. Itaru Ohta Okinawa Prefectural Fisheries Experimental Station Itoman, Okinawa	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/04/02 - 10/13/02	Dr. Leif Nottestad Institute of Marine Research Bergen, Norway	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
09/26/02 - 10/09/02	Dr. Nathaniel Newlands Pacific Institute of the Mathematical Sciences (PIMS) Vancouver BC, Canada	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish
10/05/02 - 10/10/02	Dr. Francois Gerlotto Institut de Fomento Pesquero (IFOP) Valparaiso, Chile	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/04/02 - 10/10/02	Dr. Lorenz Hauser University of Washington Seattle, Washington	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/07/02 - 10/11/02	Dr. Julia Parrish University of Washington Seattle, Washington	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/12/02 - 10/19/02	Dr. Derek Goring Christchurch New Zealand	Collaborate with Dr. Mark Merrifield and other UHSLC researchers and present a seminar entitled "Variability of Sea-Level Around New Zealand"
10/04/02 - 10/14/02	Dr. Iain Couzin Princeton University Princeton, New Jersey	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
10/02/02 - 10/15/02	Laurence Vicens Centre de Recherche Halieutique Sete Cedex France	Collaborate with PFRP scientists and attend Current Status & New Directions for Studying, Schooling and Aggregation Behavior of Pelagic Fish Workshop
12/03/02 - 12/09/02	Dr. Julian Metcalf CEFAS Lowestoft Laboratory Suffolk, United Kingdom	Collaborate with PFRP scientists and was invited as a guest speaker at the Pelagic Fisheries Research Program's Annual Principal Investigators Meeting and Workshop
12/03/02 - 12/07/02	Dr. James M. Anderson Institute of Pathology Cleveland, Ohio	Collaborate with PFRP scientists and was invited as a guest speaker at the Pelagic Fisheries Research Program's Annual Principal Investigators Meeting and Workshop
12/04/02 - 12/08/02	Dr. Kurt Schaefer Inter-American Tropical Tuna Commission (IATTC)	Collaborate with PFRP scientists and was invited as a guest speaker at the Pelagic Fisheries Research Program's Annual Principal Investigators Meeting and Workshop
12/04/03 - 12/09/02	Dr. Laurent Dagorn IRD – Sete Cedex France	Collaborate with PFRP scientists and attend Principal Investigators Annual Meeting and Workshop
11/25/02 - 12/08/02	Dr. Christopher Harvey-Clark Dalhousie University Nova Scotia, Canada	Collaborate with PRFP scientists and was invited as a guest speaker at the Pelagic Fisheries Research Program's Annual Meeting and Workshop

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
12/02/02 - 12/09/02	Dr. Keith Stoodley Lotek Wireless Newfoundland Canada	Collaborate with PFRP scientists and an invited as a participant to the Annual Principal Investigators Meeting and Workshop
12/02/02-12/10/02	Dr. Frederick Voegeli Vemco Ltd Shad Bay NS Canada	Collaborate with PFRP scientists and invited as a participant to the Annual Principal Investigators Meeting and Workshop
12/01/02 - 12/04/02	Dr. Joseph Luczkovich East Carolina University Greenville, North Carolina	Invited Collaborator and attended Acoustical Society of America Iberoamerican Federation of Acoustics Mexican Institute of Acoustics Cancun Mexico
12/01/02-12/04/02	Dr. Mark Sprague East Carolina University Greenville, North Carolina	Invited Collaborator and attended Acoustical Society of America Iberoamerican Federation of Acoustics Mexican Institute of Acoustics Cancun Mexico
12/02/02 - 12/09/02	Dr. Robert Todd Lindstrom St. Johns, Newfoundland Canada	Collaborate with PFRP scientists and invited as a participant to the Annual Principal Investigators Meeting and Workshop
12/23/02-02/21/03	Dr. Xiaodong Li Peking University Beijing, China	Collaborate with Dr. Bin Wang and other JIMAR/IPRC researchers on ENSO and Tropical Cyclone Variability
01/11/03-01/20/03	Dr. Felipe Galvan-Magana Centro Interdisciplinario De Ciencias Marianas Fisheries La Paz Baja, Mexico	Meet with Ecuador and Panama City commercial fishing operators to establish collaboration for PFRP research projects
01/11/03-01/20/03	Dr. Robert Olsen Inter-American Tropical Tuna Commission (IATTC) La Jolla, CA	Meet with Ecuador and Panama City commercial fishing operators and captains to establish collaboration for PFRP research projects
01/12/03-01/19/03	Dr. Greg Holland Aerosonde Ltd. Nottinghill Australia	Collaborate with JIMAR Scientists and other UH scientists on scientific problems of mutual interest
01/10/03-03/09/03	Dr. Daniel Huppert University of Washington Seattle, Washington	Collaborate with JIMAR/NMFS researchers on an economic analysis of area closures as fishery management and marine resource conservation measures in Hawaii
01/19/03-02/19/03	Dr. Rui Xin Huang Woods Hole Oceanographic Institute Woods Hole, Massachusetts	Collaborate with Dr. Fei Fei Jin and Dr. Bo Qiu and other JIMAR scientists on Ocean Circulation Dynamics of Equatorial Ocean Circulation
01/18/03-01/27/03	Dr. Masahiro Watanabe Hokkaido University Hokkaido, Japan	Collaborate with Dr. Fei Fei Jin and other UH scientists on ongoing issues of the transient eddy-mean flow interaction.
01/28/03 - 02/06/03	Dr. Ho Lin National Taiwan University Taipei, Taiwan	Collaborate with Dr. Bin Wang and other JIMAR/IPRC scientists to work on revising paper being submitted to <i>Journal of Climate</i>
02/09/03-02/12/03	Dr. James Foster University of Hawaii	Attended 83 rd Annual meeting of the American Meteorological Society (AMS) to present abstract
03/07/03 - 03/19/03	Dr. Daniel Lindstrom Silliman University Dumaguete City, Philippines	Candidate for a SOEST faculty position Fisheries Curriculum Coordinator that was invited to interview with the selection Committee, faculty at the UH Manoa and Hilo campuses and National Marine Fisheries Services and other government fishery representatives

DATES	NAME/AFFILIATION	PURPOSE OF VISIT
3/09/03 - 3/16/03	Dr. Nathan Evans University of South Pacific Suva, Fiji	Candidate for a SOEST faculty position Fisheries Curriculum Coordinator that was invited to interview with the selection Committee, faculty at the UH Manoa and Hilo campuses and National Marine Fisheries Services and other government fishery representatives
3/18/03 - 3/21/03	Dr. Jules Jaffe University of San Diego San Diego, California	Invited as a participant to attend the first organization meeting of the Fish Aggregating Devices as Instru mented Observatories (FADIO) held in Sete France at the Institut de recherché Pour le Development (IRD)
4/22/03 - 4/25/03	Dr. Hendrik Tolman National Centers for Environmental Predictions Camp Springs, Maryland	Collaborate with JIMAR Scientists, HIGP staff members and Meteorology staff members and also presented a seminar entitled "Ocean Wave Modeling NCEP: Wavewatch III"

Appendix III. SEMINAR LIST

July 1, 2002 to June 30, 2003

DATE	NAME/AFFILIATION	TITLE
07/29/02	Dr. T. N. Krishnamurti Florida State University Department of Meteorology Tallahassee, Florida	Multimodel Approach to the Cumulus Parameterization Issue
08/22/02	Dr. Stephen Chiswell National Institute for Water and Atmospheric Research Wellington New Zealand	Oceanographic Mechanisms for Maintaining New Zealand Rock Lobster Population
01/15/03	Dr. Greg Holland CEO and CHAIRMAN Aerosonde Ltd.	Latest Development at Aerosonde
04/22/03	Dr. Hendrik L. Tolman National Centers for Environmental Predictions	Ocean Wave Modeling NCEP: Wavewatch III

Appendix IV. WORKSHOPS AND MEETINGS HOSTED BY JIMAR

July 1, 2002 to June 30, 2003

CURRENT STATUS AND NEW DIRECTIONS FOR STUDYING SCHOOLING AND AGGREGATION BEHAVIOR OF PELAGIC FISH

October 7, 2002 to October 9, 2002

Patrice Brehmer
Richard Brill
William Burgess
Iain Couzin
Laurent Dagorn
Francois Gerlotto

Lorenz Hauser Kim Holland John Hunter Erwan Josse Pierre Kleiber Nathaniel Newlands Leif Nottestad Itaru Ohta Julia Parrish Carlos Robinson John Simmonds Marc Soria Rune Vato Laurence Vicens

John Hampton

PELAGIC FISHERIES RESEARCH PROGRAM PRINCIPAL INVESTIGATORS WORKSHOP 2002

December 4, 2002 to December 6, 2002

John Sibert Hans Malte Christina Larsen Sam Pooley Dean Grubbs David Kerstetter Joseph O'Malley Kim Holland Peter Ward Keiichi Nemoto Don Hawn Molly Lutcavage Yoav Wachsman Bob Nishimoto David Welch Naresh Pradham Julian Metcalf Laurent Dagorn Khem Sharma David Itano Wes Pratt **PingSun Leung** Michael Domier Yonat Swimmer Michael Seki Shiham Adam Markus Horning Jeff Polovina Eric Prince Chris Harvey-Clarke David Foley Heidi Dewar Jim Anderson Valeria Allen Kurt Schaefer Keith Bigelow Chris Moyes Stewart Allen Anders Nielsen Mike Musyl Paul Bartram Ram Myers **Richard Brill** John Kaneko Naomi Clear

Appendix V. JIMAR ORGANIZATION

Senior Fellow Roster	Term Expires
NOAA	
Dr. Eddie Bernard	03/31/2005
Dr. Frank Schwing	06/30/2005
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.	08/30/2003
Dr. Michael McPhaden	06/30/2005
Dr. Dennis Moore	06/30/2003
Dr. Jeffrey Polovina	11/30/2004
Dr. Mark Powell	08/31/2003
University of Hawaii	
Dr. Gary Barnes	08/31/2003
Dr. Steven Businger	10/31/2004
Dr. Eric Firing	03/31/2005
Dr. Charles Fletcher, III	12/31/2004
Dr. Fei-Fei Jin	08/31/2003
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	10/31/2003
Dr. Jagadish Shukla	10/31/2003
Dr. Akimasa Sumi	10/31/2003
Dr. Michio Yanai	10/31/2003
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. Bin Wang	12/31/2004
Dr. Thomas Schroeder	(ex officio)

Appendix VI. JIMAR PERSONNEL

Research Scientists

Michael Bevis, Researcher Develop Real-Time Water Using GPS Pao-Shin Chu, Researcher Use Hawaii-State Rainfall Eric Firing, Researcher ADCP Work During GASEX-II Project Peter Hacker, Researcher Establishment of a Data & Research Center (IPRC), JASMINE: Upper Ocean Survey Mike Hamnett, Researcher Methods for Assessing Impact Climate Variability & Change Kim Holland, Researcher Hawaii Regional Tuna Tagging Project; International Workshop on How to Improve Studies; Trophic Ecology & Structured-Associated Tuna in Hawaii Waters Fei-Fei Jin, Researcher Coupled Dynamics of Climate State Asymmetry & ENSO, Decadal Ocean-Atmosphere Interaction in the Atlantic, Dynamics of Pacific Decadal Climate Ping Sun Leung, Researcher Modeling Longline Effort Dynamics & Protected Species Inter Yuan-Hui Li, Researcher Penetration Anthropogenic CO2 in Oceans Julian McCreary, Researcher Establishment of a Data & Research Ctr. (IPRC) Mark Merrifield, Researcher ENSO Observing System: In-Situ Sea Level Thomas Schroeder, Director Climate Prediction to Operational Climate Forecasting; Climatic Change & Ecosystem Variability North Pacific; Coral Reef Management Initiative; Fisheries Oceanography: Hawaiian Monk Seal Program; Fisheries Oceanography: Protected Species-Marine Turtle Research Program; Fisheries Oceanography: Sea Turtle-Longline Interactions; Fisheries Oceanography: Swordfish Research; Hawaii Regional Coast Watch; JIMAR Administration; JIMAR Visiting Scientist; MARDAP: Cooperative Research; MARDAP: Don't Duck Metadata Project; MARDAP: Economics of Fisheries Initiative; MARDAP: Lobster Research Program; MARDAP: Pelagic Fisheries EFH Research Program; MARDAP: Research Support; NWS Ed Support – G & G; NWS Ed Support – Meteorology; NWS Ed Support - Ocean; NWS: Pacific International Desk; PRECI: Protected Resources Environment Compliance Initiative; Profiling Float Delayed-Mode Salinity Calibration; Satellite Remote Sensing Research Program; Sustaining Healthy Coastal Ecosystems; Western Pacific Fishery Information Project John Sibert, Researcher Causes of Rapid Declines in World Billfish Catch Rates; Comparison of Catch Rates Target & Incidentally Taken Fishes; Develop Hierarchical Model Estimate Sea Turtle Rookery; Develop Tools Assess Sex & Maturational Bigeye Tuna; Development Oceanographic Atlases; Dist., Hist., & Recent Catch Trends with Six Taxa; Ecological Characterization of American Samoa's Albacore; Economic Fieldwork Pelagic Fisheries in Hawaii; Eval Biochemical & Physiological Predictors Released Blue Marlin; Incidental Catch of Non-Target Fish Species & Sea Turtles; Integrated Statistical Model for Hawaiian Albatross Populations; Life History and Ecology of Opah and Monchong; Oceanic Charac.

American Samoa Longline Fishing Grounds – Albacore; PFRP Management; PFRP Modeling & Tag Design; Pop-Off Satellite Archival Tags; Population Biology Pacific Sharks; Predictors Long Term Survival in Released Blue Shark; Recreational Fisheries Meta Data; Role of Oceanography on Bigeye Tuna; Sociological Baseline of Hawaii's Longline Fishery; Survivorship, Migrations, and Diving Patterns Sea Turtles; Trophic Structure & Tuna Movement Cold Tongue-Warm Pool

- Bin Wang, Researcher Interdecadal & Biennial Variability of ENSO, Remote Forcing Warm Season Rainfall
- Shang Ping Xie, Researcher Effects of Andes on the Eastern Pacific Climate; Roles of Ocean-Atmosphere-Land Interaction

Research Support

M. Shiham Adam, Assistant Researcher JIMAR Visiting Scientist

- Soon Il An, Associate Researcher Interdecadal & Biennial Variability
- Jacob Asher, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Carole Berini, Research Technician MARDAP: Lobster Research Program
- Cindy Bessey, Associate Fishery Biologist Climate Change & Ecosystem Variability North Pacific
- Scott Bloom, Coral Reef Resource Management Specialist Coral Reef Management Initiative
- Carlin Campbell, Research Technician MARDAP: Lobster Research Program
- Stephane Charette, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Joseph Chojnacki, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Thomas Claborn, Research Technician MARDAP: Lobster Research Program
- Jason Coburn, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Carolyn Cornish, Logistics and Support Specialist Fisheries Oceanography: Hawaiian Monk Seal Program, MARDAP: Lobster Research Program
- Stephen Cotton, Fishery Specialist Sustaining Healthy Coastal Ecosystems
- Thu-Huong Crumpton, Interpreter MARDAP: Economics of Fisheries Initiative
- Daniel Curran, Fishery Biologist V Fisheries Oceanography: Sea Turtle–Longline Interactions, Recreational Fisheries Meta Data
- Kelly Curtis, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Mark Defley, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Gary Dill, Fishery Assistant IV Trophic Ecology & Structured–Associated Tuna in Hawaii Waters
- Tracy Dorigo, Research Technician MARDAP: Lobster Research Program
- Matthew Dunlap, Coral Reef Habitat Specialist Sustaining Healthy Coastal Ecosystems

Shandell Eames, Sea Turtle Research Specialist Fisheries Oceanography: Protected Species – Marine Turtle Research Program
Angela Faanunu, Statistical Assistant Methods for Accessing Impact Climate Variability & Change
James Ferguson, Systems Engineer Sustaining Healthy Coastal Ecosystems
June Firing, Junior Researcher Sustaining Healthy Coastal Ecosystems, Role of Oceanography on Bigeye Tuna
Yvonne Firing, Sea Level Research Assistant ENSO Observing System: In-Situ Sea Level
David Foley, Coastwatch Coordinator Climate Change & Ecosystem Variability North Pacific, Hawaii Regional Coast Watch, Satellite Remote Sensing Research Program
Derek Funayama, Research Assistant Remote Forcing Warm Season Rainfall
Howard Gerboc, Building Maintenance Assistant Fisheries Oceanography: Protected Species – Marine Turtle Research Program, MARDAP: Research Support
Amy Gough, Social Research Surveyor Economic Fieldwork Pelagic Fisheries in Hawaii, Sociological Baseline of Hawaii's Longline Fishery
Erich Hacker, Research Assistant ENSO Observing System: In-Situ Sea Level
Tai Suk Hahn, Interpreter Sociological Baseline of Hawaii's Longline Fishery
Amy Hall, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
Donald Hawn, Fishery Biologist Life History and Ecology of Opah and Monchong
Jefferson Hinke, Fishery Biologist Climate Change & Ecosystem Variability North Pacific
Ronald Hoeke, Oceanographer Sustaining Healthy Coastal Ecosystems
Kyle Hogrefe, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
Stephani Holzwarth, Marine Ecosystem Research Specialist Sustaining Healthy Coastal Ecosystems
Evan Howell, Remote Sensing Specialist Role of Oceanography on Bigeye Tuna
Amber Hudnall, Fishery Assistant IV Hawaii Regional Tuna Tagging Project
Patrick Hyder, Oceanographer Role of Oceanography on Bigeye Tuna
David Itano, Research Associate VI Hawaii Regional Tuna Tagging Project, Trophic Ecology & Structured-Associated Tuna in Hawaii Waters
Gayla Ivey, Research Assistant Hawaii Regional Tuna Tagging Project, Trophic Ecology & Structured-Associated Tuna in Hawaii Waters

Jerard Jardin, Sea Level Specialist	
ENSO Observing System: In-Situ Sea Leve	ł

- Jianmin Jiang, Assistant Researcher Climate Change & Ecosystem Variability North Pacific
- Jami Johnson, Research Technician MARDAP: Lobster Research Program
- Jeremy Jones, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Mario Kalson, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Lizabeth Kashinsky, Veterinary Support Specialist Fisheries Oceanography: Hawaiian Monk Seal Program, MARDAP: Lobster Research Program
- Elizabeth Keenan, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Jean Kenyon, Marine Ecologist Sustaining Healthy Coastal Ecosystems
- Bernard Kilonsky, Research Associate V ENSO Observing System: In-Situ Sea Level
- Christina Kistner, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
- Eleanor Kleiber, Social Research Assistant MARDAP: Economics of Fisheries Initiative
- Pierre Knutsson, Research Technician MARDAP: Lobster Research Program
- Steve Kolinski, Coral Reef Ecologist Coral Reef Management Initiative
- Kyle Koyanagi, Coral Reef Marine Debris Logistics Specialist Sustaining Healthy Coastal Ecosystems
- Robert Larson, Pacific International Desk Trainer NWS: Pacific International Desk
- Johannes Loschnigg, Assistant Researcher Methods for Assessing Impact Climate Variability & Change
- Walter Machado, Fishery Specialist Fisheries Oceanography: Protected Species – Marine Turtle Research Program, MARDAP: Research Support
- Lianne Mailloux, Marine Turtle Rsch. Support Asst., Sea Turtle Rsch. Specialist Fisheries Oceanography: Sea Turtle-Longline Interactions
- Sarah Malloy, Resource Management Liaison PRECI: Protected Resources Environment Compliance Initiative
- Robert Marshall, Research Technician
 - Fisheries Oceanography: Hawaiian Monk Seal Program, MARDAP: Lobster Research Program, Role of Oceanography on Bigeye Tuna, Sustaining Healthy Coastal Ecosystems
- Nikolai Maximenko, Associate Researcher Establishment of a Data & Research Center (IPRC)
- Garrett McNulty, Research Technician MARDAP: Lobster Research Program

Joyce Miller, Oceanographer Sustaining Healthy Coastal Ecosystems
Ramzi Mirshak, Atlas Coordinator Development Oceanographic Atlases
Brent Miyamoto, Research Associate/Computer Specialist ENSO Observing System: In-Situ Sea Level
Megan Moews, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
Russell Moffitt, Atlas Coordinator Development Oceanographic Atlases
Lucas Moxey, Coastwatch Coordinator, Atlas Coordinator Development Oceanographic Atlases, Role of Oceanography on Bigeye Tuna
Shawn Murakawa, Marine Turtle Research Specialist Fisheries Oceanography: Protected Species – Marine Turtle Research Program
Michael Musyl, Senior Researcher Evaluating Biochemical & Physiological Predictors Released Blue Marlin, Fisheries Oceanography: Sea Turtle-Longline Interactions, Pop-Off Satellite Archival Tags, Population Biology Pacific Sharks
Carla Navarro, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
Keiichi Nemoto, Fishery Economist MARDAP: Economics of Fisheries Initiative
David Nichols, Resource Management Specialist Coral Reef Management Initiative, PRECI: Protected Resources Environment Compliance Initiative
Stori Oates, Marine Mammal Research Coordinator Fisheries Oceanography: Hawaiian Monk Seal Program
Joseph O'Mally, Research Associate MARDAP: Lobster Research Program, MARDAP: Economics of Fisheries Initiative
Kimberly Page, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems
Denise Parker, Research Associate III Fisheries Oceanography: Protected Species – Marine Turtle Research Program
Fee Yung Porter, Research Associate/Computer Specialist ENSO Observing System: In-Situ Sea Level
Anja Reissberg, Specialist Methods for Accessing Impact Climate Variability & Change
Bradley Ryon, Resource Management Liaison PRECI: Protected Resources Environment Compliance Initiative
John Schlosser, Research Technician MARDAP: Lobster Research Program
Gregory Schorr, MDR Operations Manager Sustaining Healthy Coastal Ecosystems
Robert Schroeder, Senior Reef Fish Researcher Sustaining Healthy Coastal Ecosystems
Jennifer Schultz, Fishery Research Surveyor Recreational Fisheries Meta Data

Anita Sederstrom, Specialist PFRP Management

Karen Shepley, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems

Amanda Southwood, Assistant Researcher Fisheries Oceanography: Sea Turtle-Longline Interactions

Jennifer Stephenson, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems

Jana Yonat Swimmer, Fishery Biologist Fisheries Oceanography: Sea Turtle-Longline Interactions

Molly Timmers, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems

Nikolai Turetsky, Sea Level Technical Specialist ENSO Observing System: In-Situ Sea Level

Zhibian Li Varner, Research Assistant Interdecadal & Biennial Variability of ENSO

Peter Vroom, Marine Algal Biologist Sustaining Healthy Coastal Ecosystems

Yoav Wachsman, Fishery Economist MARDAP: Economics of Fisheries Initiative

William Walsh, Assistant Researcher Dist., Hist., & Recent Catch Trends with Six Taxa; Comparison of Catch Rates Target & Incidentally Taken Fishes

Emilie Weed, Research Technician MADAP: Lobster Research Program

Casey Wilkinson, Coral Reef Habitat Specialist Sustaining Healthy Coastal Ecosystems

Richard Wilson, Coral Reef Marine Debris Specialist Sustaining Healthy Coastal Ecosystems

Annie Wong, Assistant Researcher Profiling Float Delayed-Mode Salinity Calibration, JIMAR Visiting Scientist

Maxim Yaremchuk, Associate Researcher Establishment of a Data & Research Center

Derek Young, Physical Oceanographic Research Associate ENSO Observing System: In-Situ Sea Level, NWS Education Support Fund: Oceanography

Gang Yuan, Assistant Researcher Establishment of a Data & Research Center (IPRC)

Qin Zhang, Assistant Researcher Interdecadal & Biennial Variability

Yongsheng Zhang, Atmospheric Data Specialist Establishment of a Data & Research Center (IPRC)

Yufeng Zhu, Research Assistant Remote Forcing Warm Season Rainfall

Administrative Support

	Laura Glenn, Administrative Officer JIMAR Administration
	Michele Grace, Administrative Specialist Fisheries Oceanography: Sea Turtle – Longline Interactions
	Taryn Harada, Office Assistant JIMAR Administration
	Kevin Higaki, Assistant Program/Administrative Manager JIMAR Administration
	Alison Houghton, Secretary NWS Ed Support – G&G
	Blanche Kaiura, Program Manager JIMAR Administration
	Jan Kamiya, Administrative Secretary Fisheries Oceanography: Hawaiian Monk Seal Program, MARDAP: Lobster Research Program
	Michele Kiyono, Fiscal Support Specialist JIMAR Administration
	Licia Lau, Administrative Coordinator PFRP Management
	Jenna Lee, Office Clerk JIMAR Administration
	Tanya Maiava, Project Administrative Assistant Sustaining Healthy Coastal Ecosystems
	Sheila Matsukawa, Administrative Secretary Fisheries Oceanography: Sea Turtle – Longline Interactions, Fisheries Oceanography: Swordfish Research, JIMAR Visiting Scientist
	Norma Sakamoto, Administrative/Fiscal Support Specialist JIMAR Administration, JIMAR Visiting Scientist
	Sandra Tanaka, Administrative Specialist Fisheries Oceanography: Sea Turtle – Longline Interactions
	Naomi Yamamoto, Administrative Specialist JIMAR Administration
Com	puter Support
	Johnoel Ancheta, Computer Specialist PFRP Modeling and Tag Design
	Sun He Bak, Data Management Specialist Sustaining Healthy Coastal Ecosystems
	Kevin Bartlett, Computer Specialist JIMAR Visiting Scientist
	Arthur Betts, Scanning Assistant MARDAP: Economics of Fisheries Initiative, Western Pacific Fishery Information Project
	Nathan Chan, Technical Writer Western Pacific Fishery Information Project
	Joseph Dane, Research Programmer MARDAP: Pelagic Fisheries EFH Research Program

	Gerald Epstein, Computer Specialist IV MARDAP: Economics of Fisheries Initiative
	Nathan Foley-Mendelsshon, Computer Specialist Climate Change & Ecosystem Variability North Pacific
	Diosdado Gonzales, Computer Specialist III Western Pacific Fishery Information Project
	Craig Graham, Computer Specialist Western Pacific Fishery Information Project
	David Husby, Computer Analyst Climate Change & Ecosystem Variability North Pacific
	Phaedra Jessen, Computer Analyst Climate Change & Ecosystem Variability North Pacific
	Emi Katagihara, Data Entry Clerk ENSO Observing System: In-Situ Sea Level
	Vikram Khurana, Database Administrator/ Computer Specialist Comparison of Catch Rates Target & Incidentally Taken Fishes; Dist., Hist., & Recent Catch Trends with Six Taxa
	Crystal Kodani, Web Assistant Sustaining Healthy Coastal Ecosystems
	Ronald Merrill, Computer Systems Engineer Establishment of a Data & Research Center (IPRC)
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