

# 2011 Year in Review



# NOAA

## PACIFIC ISLANDS FISHERIES SCIENCE CENTER

*Science, Service, Stewardship*





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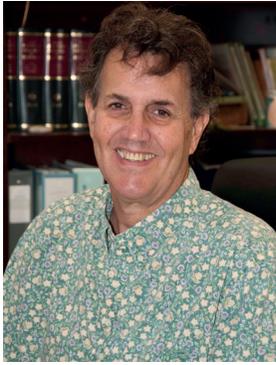
## PIFSC Mission

To conduct high-quality, timely research to support the stewardship of fisheries resources, protected species, and ecosystems in the central and western Pacific Ocean.

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Samuel Pooley, Ph.D.—Science Director



Michael Seki, Ph.D.—Deputy Science Director

## Message from the Science Director

We are pleased to present this brief overview of our research progress and achievements at the Pacific Islands Fisheries Science Center during 2011. The year was one of change, challenge, and opportunity. Our diverse staff of biologists, oceanographers, mathematical modelers, statisticians, economists and social scientists addressed many issues and made important scientific advances.

We surveyed and monitored coral reef ecosystems at Wake Atoll and the Mariana Archipelago; studied the distribution and abundance of cetaceans around Palmyra Atoll and in adjacent open ocean habitat; conducted field experiments to test innovative fishery-independent methods for estimating bottomfish populations; continued to monitor the population status of endangered Hawaiian monk seals across the Hawaiian Archipelago; explored effects of climate variables on the dynamics of loggerhead sea turtle nesting populations; produced comprehensive scientific assessments of resources to inform key management decisions; improved biological models underpinning critical fish stock assessments; and much more.

In all our scientific work, researchers were ably aided by the Center's administrators, computer systems specialists, database managers and other devoted technical support staff. Our achievements were further enabled by fruitful collaborations with partners in government, academia and the private sector. As we reach for our goals in 2012, we hope to expand on our recent progress. We will endeavor to provide our stakeholders with innovative and relevant science to meet the growing challenges of ecosystem-based resource management and marine conservation in the Pacific islands and across the nation.

Sincerely,

Two handwritten signatures in black ink. The first signature is "Sam Pooley" and the second is "Michael Seki".

NOAA

## Our Research Mission and Challenges

The mission of the Pacific Islands Fisheries Science Center is to conduct high-quality, timely research to support the stewardship of fisheries resources, protected species, and ecosystems in the central and western Pacific Ocean. Our research helps ensure that NOAA and partner organizations have a solid scientific foundation for management decisions and conservation actions affecting marine ecosystems, our economy, and Pacific island fishing communities. Our scientists are active in many research areas: coral reef ecosystem science; marine ecosystem analysis and oceanography; fisheries biology; bycatch mitigation; fisheries monitoring; economic and human dimensions research; protected species population monitoring and recovery research; climate science; and more.

The Center's research supports NOAA Fisheries Service goals in several broad areas:

**Maintaining Healthy and Sustainable Fisheries and Fishing Communities** – Our science supports domestic and international management of fisheries, enabling maximum long-term benefits to U.S. fishermen, coastal communities, the seafood industry, and consumers.

**Conserving Marine Habitats and Ecosystems** – We help build an understanding of marine habitats and associated biological communities, the ecosystem services they provide, and the forces affecting them, including climate change.

**Recovering Protected Species** – We assess and monitor populations of marine mammals, sea turtles, and other protected marine species and identify ways to restore them to healthy states.

In the following pages, we highlight some of the Center's key accomplishments in these areas of research during 2011.

Readers seeking further information on our research are welcome to visit our website at <http://www.pifsc.noaa.gov/> or send an e-mail to [Samuel.Pooley@noaa.gov](mailto:Samuel.Pooley@noaa.gov).



# Marine Habitats and Ecosystems



A significant part of the Center's research is directed at surveying, monitoring, modeling and assessing marine habitats and ecosystems in U.S. waters and open oceanic waters of the central and western Pacific. Studies range from surveys of coral reefs and pelagic habitats using NOAA vessels to complex modeling of ocean properties and impacts of climate change. During 2011, progress was noted in several areas:

## Study of Ocean Circulation Advances Understanding of Marine Debris Concentrations in North Pacific

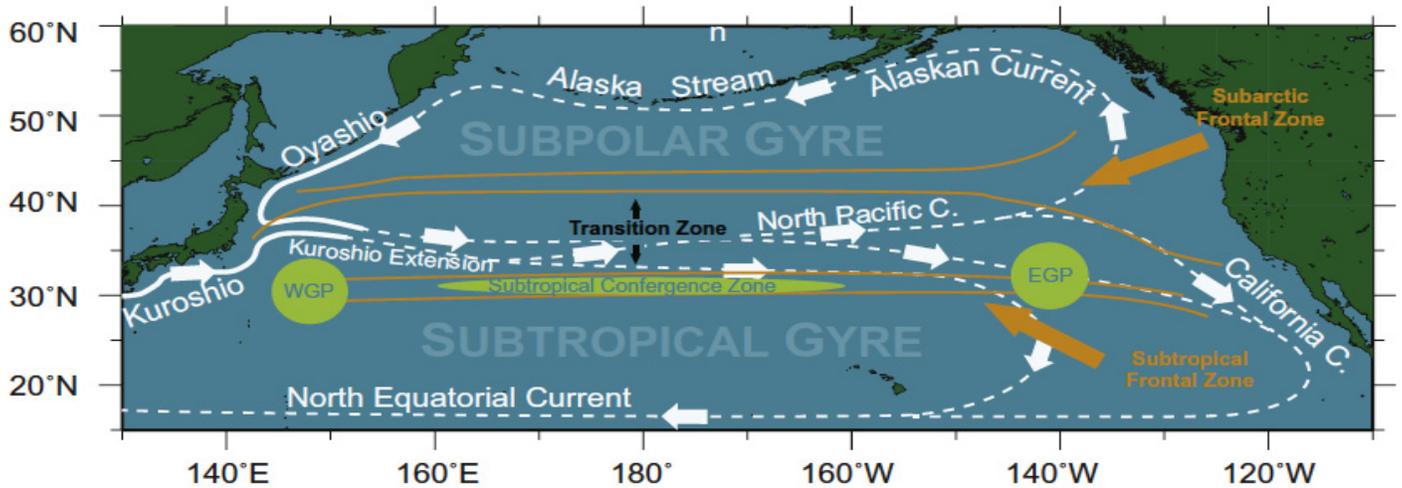
The term "garbage patch" has become familiar to many people thanks to media coverage of marine debris and its effects on ocean habitats and ecosystems. Public awareness of the issue was greatly heightened by the Tōhoku earthquake that struck northeastern Japan in March 2011, and the resulting tsunami that devastated coastal communities. The

tsunami injected an enormous amount of debris into the North Pacific. The fate of that debris is of particular interest to mariners, scientists, and conservationists. Scientists have used computer simulation models to predict the spread of the tsunami debris. The accuracy of predictions depends on how well the models take into account factors that affect debris longevity, dispersal and distribution, such as circulation patterns and effects of climate variability.

A team of PIFSC scientists and other NOAA researchers published a timely review of information on the key determinants of marine debris concentration in the North Pacific. Their 2011 research article, appearing in the peer-reviewed journal *Marine Pollution Bulletin* [1], provides key information on factors that affect the distribution of the tsunami-generated debris.

The team began their article by reviewing the primary oceanographic features and climatology of the North Pacific, including the large-scale circulation associated with the Subpolar Gyre, the more southerly Subtropical Gyre, and the Transition Zone between the two major gyres [see schematic of ocean currents]. Then they focused on the Subtropical Gyre and Transition Zone. The clockwise-rotating Subtropical Gyre is the largest circulation feature on earth and is home to the globe's largest contiguous biome. The Transition Zone is bounded north and south by various frontal systems important as foraging habitat for pelagic biota including albacore tuna, swordfish, sea turtles and seabirds.

The authors reviewed information on the convergence zones created by the large-scale circulation pattern; these are places where marine debris tends to accumulate and/or be retained. In particular, they



Ocean currents drive large-scale circulation in the North Pacific, creating a pair of major gyres joined by a transition zone. At the southern edge of the transition zone, areas of convergence are formed where marine debris accumulates. Two areas of significant debris concentration are known as the Eastern Garbage Patch (EGP) and the Western Garbage Patch (WGP).



Debris washed into the sea by the massive March 11, 2011, tsunami in northeastern Japan was initially highly concentrated. Over time, it will disperse widely across the North Pacific Transition Zone and circulate in the Subtropical Gyre in a pattern dictated by ocean currents.

described three key areas of debris accumulation: the broad Subtropical Convergence Zone along the southern edge of the Transition Zone and “garbage patches” at the eastern and western extremities of this zone. The latitudinal position of the Subtropical Convergence Zone changes seasonally, occurring farther north during the summer and

shifting southward in the winter. In some winters, the Subtropical Convergence Zone and associated frontal systems drop down into the northernmost part of the Hawaiian Archipelago with significant consequences for the local ecosystem. Primary production in the fronts may enhance biological productivity in waters surrounding the affected islands and atolls. Moreover, the convergent fronts transport accumulations of derelict fishing gear and other marine debris into the coral reef habitats where it poses a risk to endangered Hawaiian monk seals and other fauna. At the eastern end of the Subtropical Convergence Zone, marine debris accumulates in the famous “Great Pacific Garbage Patch”. And at the western end, in waters south of the Kuroshio Extension, debris is concentrated in the lesser-known “Western Garbage Patch”.

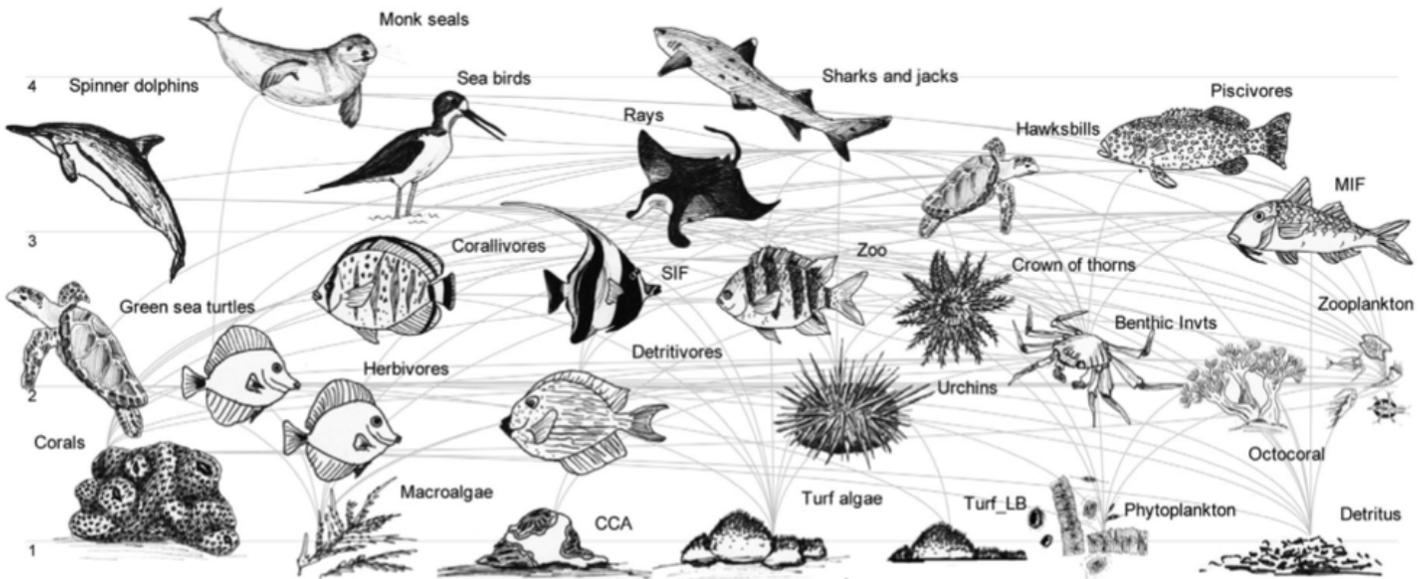
In the final part of journal article, the team described key climate drivers of variability in marine debris concentrations. In particular, they noted that interannual fluctuations in Subtropical Gyre circulation are affected by the El Niño-Southern Oscillation and larger-scale patterns are influenced by the Pacific Decadal Oscillation and North Pacific Gyre Oscillation.

In anticipation of the landfall of marine debris from the Tōhoku tsunami, NOAA and its federal and non-federal partners have launched plans to monitor the debris at sea and ashore and assess and mitigate its effects on sensitive marine ecosystems.

#### Ecosystem Model Describes Complex Linkages in Nearshore Habitat of Hawaiian Green Sea Turtles

One of the encouraging stories in conservation biology has been the marked resurgence of green sea turtles in the Hawaiian Islands, spurred by a ban on harvesting since the 1970s. Counts of nesting female green sea turtles at East Island, a key breeding site in the Northwestern Hawaiian Islands, have increased 3-fold since monitoring began 39 years ago. The abundance of green sea turtles has also increased noticeably in nearshore waters and coral reefs around the islands, where the turtles settle and reside as juveniles and adults after an early post-natal stint in the open ocean. To learn about the green sea turtle population, PIFSC scientists regularly monitor resident turtles at several coastal study sites, including





Feeding interactions between organisms in the Kaloko reef ecosystem are complex and varied. Foraging green sea turtles, herbivorous fishes, and sea urchins compete with each other for turf algae and other plant life.

one at Kaloko-Honokōhau National Historical Park (Kaloko) on the island of Hawaii. Monitoring data at Kaloko and several other sites have shown that growth rate and body condition of the turtles have diminished as turtle numbers have increased. To scientists, this suggested that the abundance of turtles at these sites may have reached the local “carrying capacity”, the maximum number of turtles the habitat is able to support.

To better understand the situation at Kaloko, a team of researchers led by a scientist from the University of British Columbia considered not just the turtles, but the entire coral reef ecosystem of which turtles are just one component. They developed a quantitative model of the ecosystem that included 26 groups of organisms at Kaloko: corals, phytoplankton, planktivorous fishes, algae of various kinds, invertebrate species like sea urchins and crabs, herbivorous fishes, corallivorous fishes, piscivorous fishes, sea turtles, seabirds, Hawaiian monk seals, spinner dolphins, and more. Information on fishing within Kaloko, though meager,

was also compiled and included in the analysis. Using a powerful modeling tool called Ecopath/Ecosim, the research team synthesized biological data for each of group of organisms for the year 2005. Then they used the model to describe the complex structure of the ecosystem, including interactions and dependencies between the various components. Along with the green turtle, primary interest was focused on the populations of algae that are the turtle’s food base and the herbivorous fishes and urchins that directly compete with green sea turtles for that forage. The model allowed the research team to estimate the abundance, consumption and productivity of each component. Herbivores accounted for 43% of all living biomass in the ecosystem with 93% of that contributed by sea urchins. Moreover, the analysis showed very high levels of ‘ecotrophic efficiency’ for macroalgae and turf algae; that is, almost all the production by these plant groups was consumed by the plant-eating fauna of the ecosystem—the herbivorous fishes, urchins, and green turtles. Thus, in the aggregate, herbivores are at their

carrying capacity within the system and exert strong competition with one another for algal resources. And green sea turtles specifically, which appear to graze mostly on turf algae growing on the nearshore lava bench at Kaloko, are at carrying capacity. This explains why the turtles are leaner and growing slower than they were in early surveys.

Shoreline developments are projected around the Kaloko-Honokōhau National Historical Park that will likely affect the coral reef ecosystem. To the extent such developments cause greater enrichment of the reef by terrestrial runoff or greater fishing pressure on herbivorous fishes, the ecosystem, particularly the algal and herbivore components, will be altered. The ecosystem model gives scientists a powerful tool for evaluating such impacts. It is important that the model includes the Hawaiian green sea turtle, as its efficiency in cropping algal resources adds to the reef’s resiliency.

The Kaloko study was published in the peer-reviewed journal *Marine Ecology Progress Series* [2].

## Surveys Document Inshore Fish Community at Remote Pacific Islands

In a series of surveys from 2000–2008, PIFSC researchers and collaborating scientists expanded our understanding of the shoreline fish fauna at several U.S. atolls in the equatorial central Pacific: Howland Island and Baker Island of the Phoenix Island group, and Jarvis Island, Palmyra Atoll and Kingman Reef of the Line Island group. Together these atolls and their surrounding waters comprise the Pacific Remote Islands Marine National Monument. Because this region is so isolated and seldom visited, relatively little is known of its biotic community and the oceanographic factors shaping its makeup. Prior to the recent surveys, a scant ichthyological record had been compiled from infrequent scientific expeditions to the region, beginning in 1864.

The PIFSC surveys were part of a comprehensive effort by the Center's Coral Reef Ecosystem Division to document and assess the biodiversity of coral reefs across the U.S. Pacific islands, including remote, uninhabited atolls and areas with populated islands like American Samoa, Commonwealth of the Northern Mariana Islands, Guam and Hawaii. During multifaceted expeditions to monitor and assess the coral reefs, teams of scuba divers were deployed during daylight to systematically identify and count non-cryptic, reef-associated fish between 3 and 20 m depth. Various survey protocols were used: free-swimming along designated transects, towed-diver surveys, rapid ecological assessment surveys, and stationary point counts. Detailed lists of identified fish species and animals higher in the food web were compiled for each island. Identifications were based mostly on visual assessment; few were substantiated by photos or voucher specimens. A variety of statistical methods were used to estimate biogeographic characteristics of fish counts at the 5 surveyed islands and compare them with those at other Pacific islands and archipelagos.

The surveys recorded 506 species of reef-associated shore-fish. A high percentage of records represented the first documented sightings of the species at these islands: 50.8% of the 328 species observed at Howland, 70.1% of the 268 species at Baker; 64.2% of the 274 species at Jarvis, 28.6% of the 395 species at Palmyra; and 78.5% of the 270 species at Kingman. Most species known to occur in the Line and Phoenix Islands but not recorded in the surveys were cryptic species; for example, nocturnal species not apt to be seen in the diurnal surveys.



Pelagic barracuda are part of the coral reef fish community in the Line Islands.

Sixty-nine percent of the fish species encountered have broad distributions across the Indo-Pacific, many ranging from east Africa to French Polynesia. Others have narrower distributions in the western Pacific; some are endemic to the region. The research team found that the 5 surveyed islands are unique among U.S. possessions in having reef fish species not seen in other U.S. waters. Some of these species are members of the endemic central Pacific fauna about which we know little. These islands are among the least-studied places on the planet. Not only are the fish communities poorly understood, but so are the oceanographic processes that influence biogeographic patterns in the species distributions and abundance. Further study of these remote U.S. atolls will advance knowledge of the ecology, biodiversity and evolution of the region's fish fauna.

The study was published in the peer-reviewed journal *Atoll Research Bulletin* [3].



Grey reef sharks were routinely observed at each of the five remote U.S. Pacific islands surveyed.

# Protected Species



*PIFSC is actively engaged in research to support the conservation of sea turtles and marine mammals in the Pacific Islands Region. Studies conducted by Center scientists support management actions of NOAA and partner agencies under provisions of the U.S. Endangered Species Act and Marine Mammal Protection Act, including recovery plans and take reduction plans. Center biologists conduct population monitoring and other research on threatened and endangered populations of sea turtles and the endangered Hawaiian monk seal. Other PIFSC researchers monitor and assess populations of cetaceans across the Region, in collaboration with the Southwest Fisheries Science Center. During 2011, progress was noted in several areas:*

## **Are Dynamics of Sea Turtle Populations Driven by Climate?**

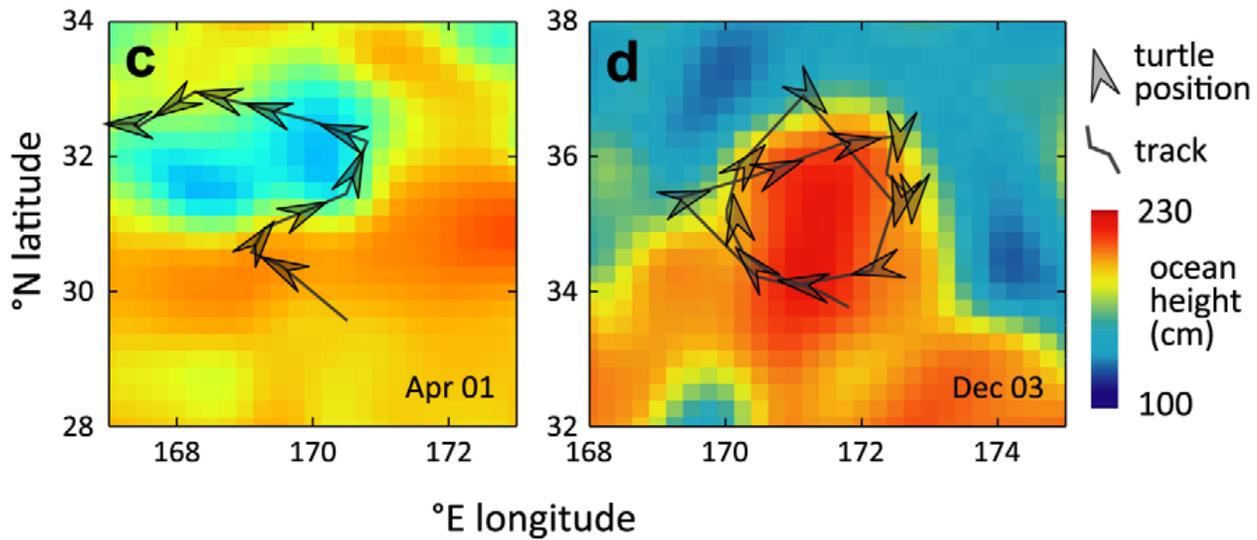
Current strategies to rebuild diminished sea turtle populations focus on causes of decline that are readily apparent and

directly amenable to human intervention; for example, restoring degraded habitat; preventing loss of eggs, hatchlings and adult females on nesting beaches; and reducing mortality of turtles caused by fishing and marine debris. The premise is that these anthropogenic factors are the main determinants of sea turtle numbers. Recent research at PIFSC has challenged that perception by showing that for loggerhead turtles in the North Pacific and Northwest Atlantic, trajectories of abundance may be dictated largely by variations in climate.

The research was conducted by a PIFSC mathematical ecologist and a colleague from the University of Ioannina in Greece. They began their study by analyzing data collected on loggerhead nesting beaches in Japan and Florida. Loggerheads born on these beaches seed the populations in the North Pacific and Northeast Atlantic, respectively. Beach

counts of nesters or nests are the primary source of information on loggerhead abundance, and trends in these counts over time are used to monitor population status. The number of females coming ashore to nest in a given year is dependent on two variables: (1) the unknown number of adult females in the population, i.e., all females recruited as juveniles in previous years that are mature and still alive, and (2) the probability that an adult female will nest in the current year. The research team postulated that each of these components is affected by certain climate conditions.

In the case of adult female loggerheads, current abundance depends partly on the fraction of post-hatchling turtles that survived their critical juvenile pelagic phase years earlier, and the team suggested that in the North Pacific this survival is tied to climate conditions measured by the Pacific Decadal



In the North Pacific, juvenile loggerheads feed along edges of cyclonic (c) and anticyclonic (d) eddies where their prey are concentrated. The occurrence of these features in the turtles' oceanic habitat is part of the climatic variability measured by the Pacific Decadal Oscillation.

Oscillation (PDO) index. The PDO index captures phase shifts in average North Pacific sea surface temperature north of 20° N and is seen as a proxy for survival of juvenile loggerheads foraging in the North Pacific. In other studies, the PDO has been correlated with biological productivity in northeast Pacific marine ecosystems. As for nesting probability, the team suggested that an adult female loggerhead's readiness to lay eggs was directly related to sea surface temperature in her foraging grounds during the winter months prior to the nesting season.

Based on these notions, the team assembled time series of the PDO index and winter SST and used them as predictors in a linear model of annual Japan loggerhead nest counts. The best-fitting model showed that relatively high nest counts were strongly associated with higher values of the PDO index 25 years earlier (the lag accounts for the years required for a female to reach maturity) and warmer SST in the preceding winter. Low nest counts were associated with lower PDO values and cooler winter SST. The full

model, with both lagged PDO index and winter SST as predictors, explained 66% of the interannual variation in Japan loggerhead nest counts during the study period. In a similar model for Northwest Atlantic loggerheads, using the Atlantic Multidecadal Oscillation (with a 31-year lag) and winter SST as predictors, the combined model accounted for 77% of variation in loggerhead counts on Florida nesting beaches. Impressively, the models captured major features of nesting variability at both decadal and interannual scales, even at a local scale on beaches where most nesting occurs.

Although environmental conditions are well known to affect turtles, (e.g., dependence of hatchling sex ratio on nesting beach temperature), effects of climate and environment have largely been ignored in current approaches to sea turtle assessment. Human-caused mortality is usually viewed as the main driver of turtle population dynamics. Moreover, the abundance of nesters is assumed to be the key determinant of future recruitment. Clearly, anthropogenic factors are an important

determinant of loggerhead abundance, but the fact that the climate-based models for North Pacific and Northeastern Atlantic loggerheads explained about 70% of year-to-year variation in nest counts, and that a high proportion of the variation was linked to climate-based proxies for recruitment success strongly suggests that a broader viewpoint is needed in sea turtle assessment and conservation.

The sea turtle research was published in 2011 in the peer-reviewed, public access journal *PLoS ONE* [4].

#### Divergence of Regional Trends in Abundance of Hawaiian Monk Seals Alters their Distribution within the Archipelago

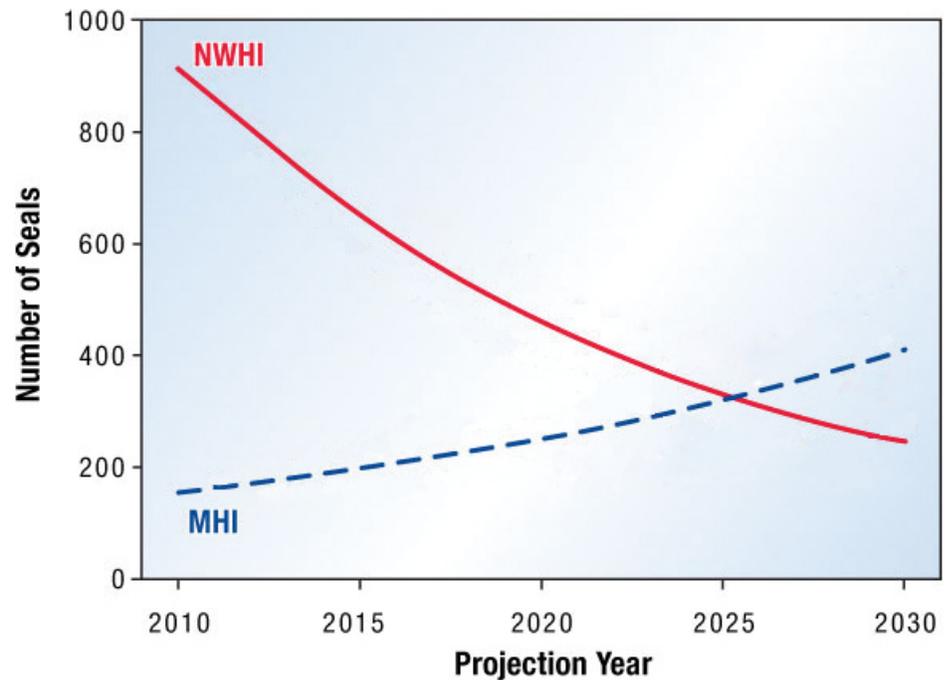
One of NOAA's major conservation goals is to reverse the decline of Hawaiian monk seals. The embattled species numbers about 1100 animals and is falling each year by 4%. If this rate of attrition were to persist, the population would be cut in half every 17 years and essentially vanish by the end of the century. To



provide the scientific foundation for monk seal recovery, PIFSC has monitored and studied seals each summer at the major breeding locations in the remote Northwestern Hawaiian Islands (French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Atoll, Midway Atoll, and Kure Atoll), where most of the seals live. Biologists observe and record the number of seals present at each breeding site, paying particular attention to newborn seals. Unique markings on the pelage enable researchers to identify individual seals each time they are encountered and trace their history.

Data collected since the early 1980s show that the population of monk seals in the Northwestern Hawaiian Islands is decreasing steadily due to several causes, but primarily from low survival of juvenile seals. At French Frigate Shoals, for example, mortality of seal pups due to shark predation has been particularly severe. Vulnerability to predation is increased for many pups by a low weight at weaning, a condition linked to lack of success in foraging by their mothers.

In contrast to the Northwestern Hawaiian Islands, the main Hawaiian Islands have seen an upswing in seal sightings and documented activity, including the birth of several pups. But little is known about this much smaller segment of the population. So in 2008, a team of PIFSC scientists also surveyed seals in the main Hawaiian Islands, assisted by partner agencies and nongovernmental volunteers. Seal sightings on Oahu, Kauai and the other accessible islands were documented and when feasible, the seal's identity and biological characteristics were established. At the privately owned island of Niihau and nearby Lehua Rock, seals were counted and photographed from the air using a U.S. Coast Guard helicopter. After analyzing the survey data, the PIFSC team estimated that a



Models of Hawaiian monk seal abundance predict a steady decline in the Northwestern Hawaiian Islands and a concurrent increase in the main Hawaiian Islands. By 2024, equal numbers of seals are expected to occur in each part of the archipelago.

minimum of 153 seals resided in the main Hawaiian Islands. The team also calculated that the main Hawaiian Island seals have higher survival than seals in the Northwestern Hawaiian Islands. In particular, weaned pups in the main Hawaiian Islands have a 77% chance of reaching their first birthday compared with only 20% for pups in the Northwestern Hawaiian Islands.

Although estimates of the current population size indicate that only 14% of Hawaiian monk seals live in the main Hawaiian Islands, PIFSC scientists predict that the distribution of seals along the archipelago will change. The research team used a computer model to forecast the population size in the main Hawaiian Islands and at each of the Northwestern Hawaiian Island breeding sites. If present rates of seal reproduction and survival remain constant, the number of seals in the main Hawaiian Islands will increase while seals in the Northwestern Hawaiian

Islands decline, with the two components reaching equal levels in about 2025. Thereafter, the majority of seals are predicted to reside in the main Hawaiian Islands.

This scenario is uncertain. The projections are based on simplifying assumptions and, in the main Hawaiian Islands, relatively meager data. Survival and other vital rates may well change over time. Optimistically, NOAA's attempts to increase pup survival in the Northwestern Hawaiian Islands may reverse the monk seal's decline there, but given the current age composition of the population, such a turnaround would take many years. Other factors at play in the Northwestern Hawaiian Islands, including changes in ocean productivity and sea level due to climate change, will affect the population also. In the main Hawaiian Islands, the seal population may continue to grow at its present vigorous pace, or it may encounter limits; the capacity of the main

Hawaiian Islands to support a larger number of seals is unknown. In any event, significant challenges lie ahead for the seals and NOAA scientists and managers seeking ways to recover the population.

The PIFSC study of monk seal population trends was published in the January 2011 issue of *Marine Mammal Science* [5].

### Surveys Confirm Wintering of Humpback Whales in the Northwestern Hawaiian Islands

The primary wintering grounds of humpback whales in the North Pacific are in the main Hawaiian Islands (MHI). The whale population has grown substantially in recent decades in the wake of a global ban on whaling. As a result, public awareness of humpback whales has increased and whales have been seen in

more inshore waters of the MHI. Studies of the population's distribution have also reached out into the Northwestern Hawaiian Islands (NWHI) and in 2007, a scientist at the University of Hawaii Joint Institute for Marine and Atmospheric Research (JIMAR) affiliated with the NOAA PIFSC published evidence of humpback whales wintering in the NWHI. He also applied a spatial habitat model to estimate the potential NWHI winter habitat for the whales. A more recent study, based on more extensive surveys, found that humpback whales are common in the NWHI during winter months and confirmed that this region is an important wintering habitat for the population.

The recent research was led by a scientist from the Hawaii Institute of Marine Biology (HIMB) and colleagues

from HIMB, JIMAR, and PIFSC. They deployed devices called ecological acoustic recorders (EARs) at 9 study sites throughout the Hawaiian Archipelago to record the occurrence of humpback whale song, an indicator of winter breeding activity. The EAR is a microprocessor-based autonomous instrument that samples and records sound in the surrounding water at pre-programmed intervals of time. The timing and abundance of song recorded at each of the EAR sites indicate that humpback whales were common in the NWHI from late December 2008 to mid-May 2009, closely following trends observed at Oahu in the MHI and strongly suggesting that the whales use the NWHI as a wintering area.

The findings of the research team were published in the peer-reviewed journal *Marine Ecology Progress Series* [6].



Humpback whales are common in waters of the main Hawaiian Islands during their winter breeding season. Recent research confirmed that the whales also winter in the Northwestern Hawaiian Islands.

# Sustainable Fisheries and Fishing Communities



*The Center carries out extensive activities to monitor U.S. fisheries throughout the Pacific Islands Region, assess the status of exploited fish stocks, and provide scientific advice to fishery managers. Fish catch and fishing effort are monitored by Center staff in collaboration with local government partners in American Samoa, CNMI, Guam, and Hawaii through the Western Pacific Fisheries Information Network. Research is conducted on fish life history and biology; mitigation of fishery interactions with protected species; fish population dynamics and stock assessment; economics and human dimensions of fisheries; and more. Substantial collaborative research on pelagic stocks is carried out through the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. Monitoring information and stock assessments support the development and implementation of domestic fishery management plans for insular and pelagic fisheries through the Western Pacific Fishery Management*

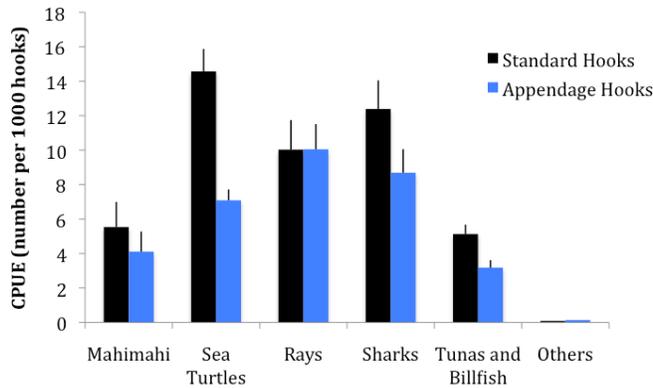
*Council. They also contribute to international management of fisheries for tunas, billfishes, and other highly migratory pelagic fish through the Western and Central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission. During 2011, progress was noted in several areas:*

## **Circle Hook Research Aims at Reduction of Longline Fishery Bycatch**

A key goal of NOAA is to find ways to sustain valuable fisheries for target species while reducing unwanted capture and incidental mortality of non-target species of fish and protected marine wildlife, such as turtles and seabirds. Research has shown that in pelagic longline fisheries, reductions in unwanted catch and related mortality can often be achieved by modifying the fishing gear and how it is deployed. In particular, circle hooks have been widely advocated as a way to reduce incidental take and mortality of sea turtles

and have been successful in doing so in the Hawaii-based shallow-set swordfish longline fishery. But in studies across several longline fisheries, the effect of circle hooks on longline catch rates and survival of non-target fish species, such as marlins, have been variable.

PIFSC scientists in the Fisheries Interaction and Conservation Program recently completed a pair of experiments to evaluate circle hooks as a means to reduce unwanted catch in pelagic longline fisheries. The first experiment was a study in the Costa Rican longline fishery. The fishery targets mahimahi and sharks, but the catch is dominated by non-target species such as sea turtles and rays. Working in collaboration with other scientists, PIFSC researchers compared catch rates for target and non-target species on 2 kinds of hooks: regular circle hooks and experimental circle hooks bearing a wire appendage extending at



In the Costa Rican longline fishery experiments, circle hooks with an appendage produced reduced catch rates of sea turtles and most other species groups.

an angle from the hook's eye. They found that the appendage circle hooks produced a lower catch-per-unit effort (CPUE) than the standard circle hooks for all species groups, except for rays; the differences were statistically significant for sea turtles and tunas and billfishes. The effectiveness of the appendage hooks in reducing turtle takes is encouraging, but further research is needed to find a solution that also maintains the economic viability of the fishery.

In a second study, PIFSC scientists conducted an experiment around the Hawaiian Archipelago to quantify effects of 3 types of hooks in the Hawaii-based tuna longline fishery: Japanese-style tuna hooks normally used by Hawaii longliners targeting bigeye tuna, J-hooks formerly used by Hawaii longliners

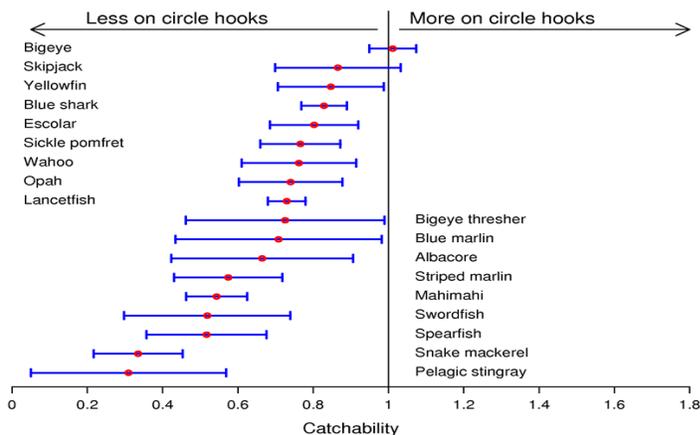
targeting swordfish, and large (size 18/0) circle hooks currently required by Hawaii shallow-set swordfish boats. Scientific observers overseen by the NMFS Pacific Islands Regional Observer Program were deployed on 16 contracted tuna longliners to collect data under a well-planned experimental protocol. When setting their gear, some vessel captains attached circle hooks alternately with tuna hooks along the mainline, so that encounters of marine life with the 2 types of hooks used would be equally likely during the set; there were 1182 such sets. Other vessels alternately deployed circle hooks and J-hooks, resulting in 211 sets comparing these hook types.

Results showed no significant differences between hook types in the average catch rate of the target species, bigeye

tuna. But for almost all non-target fish species, average catch rates on circle hooks were significantly lower than with tuna hooks. In the comparisons with J-hooks, average catch rates were higher on circle hooks for bigeye tuna and albacore, and lower for the other species. But for 10 of the 18 species, the differences in relative catchability were not statistically significant, largely due to the smaller number of comparisons. There were no differences between hook types in the average size of bigeye caught, but in general, billfishes caught on circle hooks were significantly longer than those caught on tuna hooks. For 6 species, the proportion of fish alive was significantly higher on circle hooks than on tuna hooks; indeed for 13 of the 18 species, the proportion of fish alive was lower on tuna hooks than either circle or J-hooks.

The experiment indicated that adoption of large circle hooks in the deep-set Hawaii tuna fishery for bigeye tuna could help achieve conservation goals by reducing incidental capture and mortality of billfishes, sharks and several other non-target fish species while maintaining catches of bigeye. Effects of such measures on the fleet's economic performance are uncertain. Revenues from bigeye tuna might increase; if the fish caught on circle hooks can be landed in better condition, they might command a higher ex-vessel price. On the other hand, revenues from marketed non-target species such as yellowfin tuna, opah, billfishes, and dolphinfish might be reduced unless the reduced market volumes are accompanied by higher ex-vessel prices; full economic impacts have not been assessed.

Findings from both studies were peer-reviewed and published in 2011. The Costa Rican research appeared in the journal *Marine Biology* [7] and the Hawaii longline fishery study was issued in *Fisheries Research* [8].



In the Hawaii tuna longline experiments, average catch rate of the target species, bigeye tuna, was slightly higher on circle hooks than on tuna hooks. For all other species, catchability on circle hooks was lower.



### Socioeconomic Surveys Reveal Characteristics of Hawaii's Small Boat Pelagic Fishery

To craft effective fishery regulations, managers need a full understanding of economic and social dimensions of the fishery and fishing community. To provide such a foundation for management of Hawaii's pelagic fisheries, PIFSC scientists conducted a survey of costs and earnings in the small-boat pelagic fishing fleet. To measure seasonal variation, the survey was carried out in two segments, one during the summer of 2007 and the other during the winter of 2007–2008. Fishers were interviewed at boat ramps across the State of Hawaii as they returned from fishing excursions. In each interview, researchers gathered information on the fishing vessel used and its operating characteristics, fixed and variable costs associated with fishing and maintenance of the vessel, amount of fish caught, disposition of the

catch, demographic characteristics of the participants, and more. The survey targeted motorized vessels under 40 ft, and excluded charter boats. Almost all vessels in the study made single-day or single-night trips.

Survey results enabled the research team to estimate the proportions of fishermen who were commercial fishers (those who sell fish) versus recreational (or non-commercial) fishers, based on the fishers' self-classification and their actual observed behavior. They also provided a statistical basis for characterizing each group of fishermen. Of the 343 interviewed fishers, 42% self-classified themselves as commercial fishermen, yet 60% of all respondents actually had sold fish in the past year. And about 30% of fishers who considered themselves as recreational had sold fish in the past year. Survey respondents reported making 55

fishing trips in the past year, on average; commercial fishers took significantly more trips than noncommercial fishermen. Commercial trips were also longer than recreational trips, but did not cost significantly more. About 47% of fishers reported using more than one type of fishing gear during the past year. Pelagic fish accounted for about 80% of the previous year's total catch and fuel costs made up 66% of average pelagic fishing trip expenditures. Average gross revenues of commercial fishers just defrayed their annual costs; few fishermen profited from fishing. Most respondents said they sold their catch to cover trip expenses, and that profit was not their primary motive for fishing. On average, only 19% of personal income of commercial fishers resulted from fishing.

Small-boat fishers landed 3.4 million pounds of fish in 2006, generating



Yellowfin tuna (ahi) are a favorite target of Hawaii's recreational fishermen.

revenues of \$6.8 million. Almost all fishers appeared to participate in a fish sharing network with friends and relatives and more than 62% considered their catch to be an important source of food for their family. Although most of the commercial catch was sold to Hawaii restaurants and retail outlets, 38% was consumed by fishers and their families and shared with friends. The research team concluded that a simple classification of small-boat fishers into commercial and recreational categories is an insufficient basis for management analysis; managers should take into account the various cultural motivations that govern participation in the fishery and disposition of the catch.

The survey results were published in a Center technical report [9].

### Tagging Study Measures Post-release Survival of Oceanic Sharks

In the Hawaii-based longline fisheries targeting tuna and swordfish, some sharks are also kept for sale, but most are discarded. Managers taking an ecosystem-based approach to management of the fishery need to take into account the bycatch mortality—the probability that fish caught but released alive by fishermen will subsequently die as a result of capture. Such information is particularly needed for sharks, given their key role as top-level predators in the ecosystem. In a recent study led by researchers at PIFSC, important progress was made in understanding post-release mortality of pelagic sharks caught by longline gear.

In the study, a research team analyzed data from pop-up satellite archival tags (PSATs) placed on 71 sharks caught and released in the central Pacific Ocean. The sharks represented five pelagic species: blue shark, shortfin mako shark, silky shark, oceanic whitetip shark, and bigeye thresher shark. The tags were deployed during research expeditions by the NOAA Ships *Townsend Cromwell* and



Pop-up tags were placed on pelagic sharks, like this oceanic whitetip, to study their likelihood of survival after release.

*Oscar Elton Sette* from 2001 to 2006. Most fish were caught at depths less than 100 m, hoisted aboard the vessels in a sling, then tagged and released; bigeye threshers were tagged while in the water alongside the vessel, using a harpoon. The PSATs were programmed to record information on water temperature and depth every 15-60 minutes and to release from the fish and pop up to the sea surface after 8-13 months of deployment. Tags would also release if the tag remained at a constant depth (indicating tag loss) or sank below 1200 m and remained there longer than 15 minutes (implying fish mortality). After surfacing, tags transmitted their data payload to ARGOS computers via satellite.

PSAT data showed that the 5 species occupied different but overlapping oceanic habitats with respect to depth and temperature. Moreover, vertical migration patterns varied temporally and spatially among individual sharks. These patterns were affected by oceanographic phenomena, such as El Niño-Southern Oscillation. The species can be grouped broadly based on their daytime preferred temperature range as follows: silky sharks and oceanic whitetip sharks (both epipelagic species) spent 95% of their daylight hours in waters within 2 °C of the

sea surface temperature; blue sharks and shortfin mako sharks (both mesopelagic-I species) spent 95% of their time in waters ranging between 9.7 °C and 26.9 °C, and 9.4 °C and 25.0 °C, respectively; bigeye thresher sharks (a mesopelagic-II species) spent 95% of their time in water between 6.7 °C and 21.2 °C. The PSAT data also suggested that the epipelagic species occupied particular thermal niches depending on their body size and latitude.

Of the 71 PSATs deployed in this study, 44 popped off and reported data, including 16 on blue sharks. Only one of the 44 reporting tags indicated mortality of the fish, and that was on a blue shark. Combining data for the 16 reporting blue shark tags in this study and 62 others in previously published reports, a summary estimate of post-release mortality for blue sharks was calculated at 15% (with a 95% confidence interval of 8.5–25.1%). This result, and the apparent absence of post-release mortality for other species in this study (28 reporting PSATs), suggests that catch-and-release can be a viable strategy for reducing incidental mortality of sharks in longline fisheries.

The study was published in the peer-reviewed journal *Fishery Bulletin* [10].



## Other Notable Accomplishments



### External Review of Sea Turtle Research and Monitoring

In July 2011, PIFSC invited a panel of independent experts, external to the Center, to review and evaluate the Center's approaches to research on sea turtle population modeling, population monitoring, and by-catch mitigation. Panelists were asked to advise Center leadership on ways PIFSC could improve our work in this important area of conservation and management science. In sessions open to PIFSC staff and stakeholders, the panel heard oral presentations by PIFSC staff describing the Center's multifaceted sea turtle research program, including studies on inshore and pelagic ecology, population monitoring, population assessment, bycatch mitigation in longline fisheries and net fisheries, effects of oceanography and climate, and more. The presentations focused on four species: Hawaiian green

sea turtles, loggerhead turtles, leatherback turtles, and hawksbill turtles.

The panel also met privately with key PIFSC stakeholders to learn candidly how well the Center is doing in meeting our clients' needs. At the conclusion of the review, the panel chair prepared a report with consensus views and advice of the experts.

The external review helped the Center focus sharply on ways to improve its marine turtle research and particularly how to do so in the face of increasing fiscal challenges. We have already set out to implement many of the panel's recommendations.

### Center Reorganization

In 2011, as in the previous year, we made significant organizational changes to improve our effectiveness in addressing the Center's research

mission. Previously, our Information Technology (IT) functions and core administrative functions were carried out by separate divisions. In 2011, these were consolidated through creation of a single Operations, Management and Information Division. The new division has an assortment of management and administrative responsibilities: maintaining computer, network and communications infrastructure across the Center; compliance with government IT security protocols; management of Center purchases; procurement and property management; personnel services; grants management; diversity and training; travel management; facilities management and maintenance; and safety and environmental compliance. As part of the reorganization, management of diver safety and the Center's small boat program were handed over to the Scientific Operations Group under the Directors Office.

## Summer Internship Program

The Center's summer internship program for university undergraduate students made notable strides forward during its third year of operation. In the summer of 2011, the program hosted three outstanding young scientists from the University of Washington, Cornell University, and Stanford University. Under the mentorship of PIFSC staff, each intern tackled a challenging research project related to their own interests and the science mission of the Center. Their work encompassed a range of topics: analysis of biosampling data from Guam fisheries; analysis of towboard images from coral reef surveys at Rose Atoll in American Samoa; and physical oceanography of the Kona Coast of the Big Island of Hawaii. Before returning to school for the fall semester, the interns presented their research findings at a special PIFSC symposium.

## New Ford Island Facility

PIFSC continued to have significant involvement in preparations for the new NOAA Pacific Regional Center at Ford Island, Pearl Harbor, which will soon be home to all PIFSC staff, along with other NOAA workers in Honolulu. Significant

progress on construction of the new facility has been made and completion is expected in late 2013. In February 2012, the first phase of the project, a Marine Science and Storage Facility, was completed and celebrated in an open-house ceremony attended by NOAA officials, Hawaii congressional staff, and key stakeholders. Besides providing specially designed tanks to house marine life for research projects, the first-phase addition will enable storage of equipment needed for research expeditions on the NOAA ships now berthed at Ford Island adjacent to other components of NOAA.

## Research Support: Administration, Information Technology, and Other Services

Our scientists could not achieve NOAA's mission without the help of an able and dedicated support staff. During 2011, our administrative staff managed budgets, enabled travel, procured equipment, managed facilities and small boat operations, ensured safety of the workplace, and provided other critical support. Research projects were aided by a computer systems staff that maintained the Center's information and communication infrastructure, including hardware and software, networks, security protocols, and other critical

assets at our main Dole Street offices and 5 satellite office and laboratory complexes elsewhere on Oahu. Other key support was provided by our scientific information specialists who managed our public library; prepared graphics and outreach materials; ensured that results of Center research were properly prepared, edited, and disseminated through peer-reviewed journals, Center technical reports, and our website; ensured timely availability of data for fishery monitoring; coordinated the collection and publication of metadata; assisted Center staff and partners with data queries; improved software tools that helped users tap directly into the Center's Oracle enterprise database; and more.

## Partnership with University of Hawaii Continues under New NOAA Cooperative Institute

For more than 2 decades, the Pacific Islands Fisheries Science Center has enjoyed a fruitful partnership with the University of Hawaii's Joint Institute for Marine and Atmospheric Research (JIMAR). In 2011, JIMAR's tenure as one of NOAA's 18 Cooperative Institutes ended, but the University was successful in an open competition to host a new Cooperative Institute for the Pacific Islands Region. The award is for a 5-year period. The new research organization is known by the same name as its predecessor—JIMAR.

JIMAR conducts research in many areas germane to NOAA's mission. One of its key partnerships is with PIFSC. JIMAR collaboration with PIFSC provides much of the science needed for conservation and management of living marine resources in the central and western Pacific. The research has focused on many critical areas, including monitoring and assessment of fish stocks, studies of coral reef ecosystems, and ecology of protected species.



Seawater tanks at the new Pacific Regional Center on Ford Island will support live-animal research.

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## NOAA Fisheries Service Vision:

The American people enjoy the riches and benefits of healthy and diverse marine ecosystems.

Copies of this document may be obtained by contacting:

Pacific Islands Fisheries Science Center  
2570 Dole Street  
Honolulu, HI 96822-2396  
Ph: (808) 983-5303

An online version is available at <http://www.pifsc.noaa.gov/do/index.php>

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