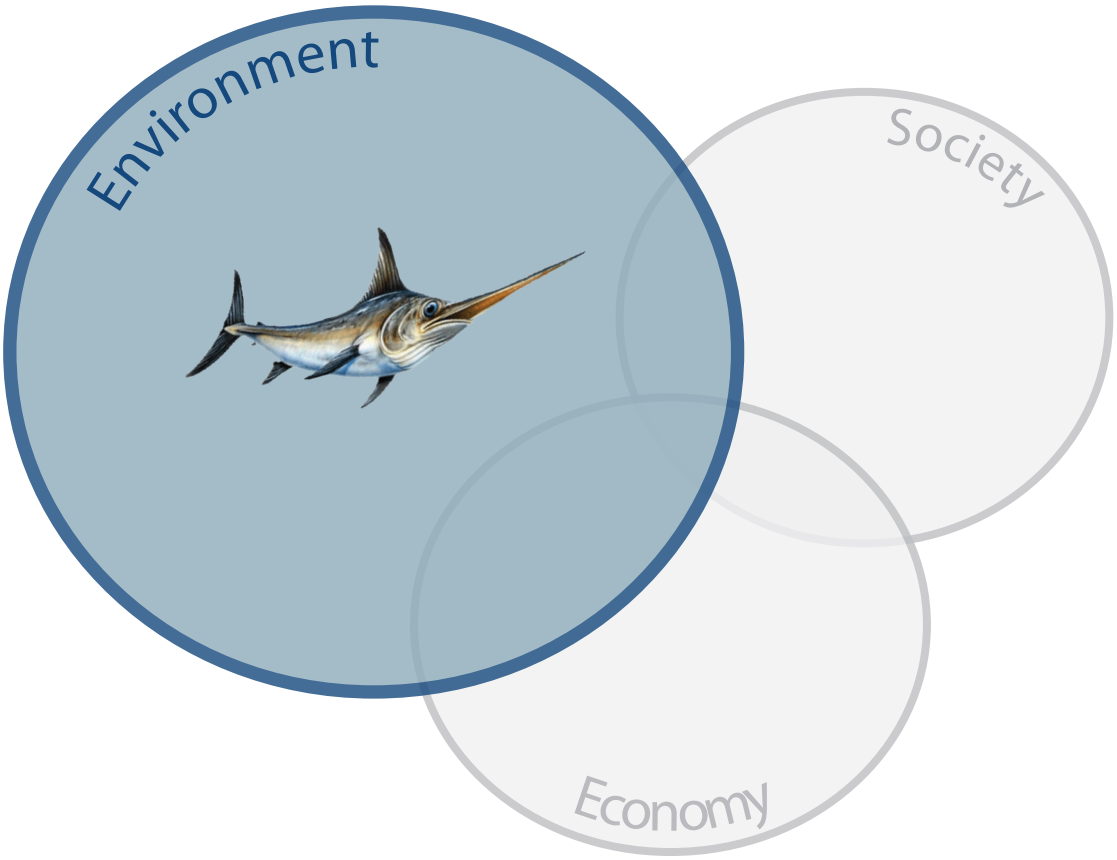


Ecological Factors:
Fishery Interactions and Minimizing Ecosystem Impacts

This session reviewed current information about the ecological factors in the fishery. Topics included tools and strategies used to assess the risk of various marine activities to protected species; developing more selective fishing gear and methods; shark bycatch rates and susceptibility to the fishery; and a summary of a 2008 NMFS workshop that focused on the shared habitat of swordfish and leatherback sea turtles along the U.S. west coast.

Session Speakers

Dr. Jessica Redfern leads the Ecosystem Studies Program in the Protected Resources Division at the NMFS Southwest Fisheries Science Center. The modelers, marine ecologists, and oceanographers in this group use ecosystem data to interpret trends in marine mammal abundance and predict the location of these animals. Jessica's research investigates the factors influencing marine mammal distributions in the eastern Pacific Ocean.

Dr. Suzanne Kohin is a fishery biologist and leads the Highly Migratory Species Research Program at the NMFS Southwest Fisheries Science Center. Her research group focuses on fishery data management, population status, and life history of tunas, billfish, and pelagic sharks encountered in U. S. and international marine fisheries for tuna and tuna-like species. Suzanne obtained her doctorate in biology and physiological ecology at the University of California, Santa Cruz.

Dr. Chugey Sepulveda is the senior research biologist at the Pfleger Institute of Environmental Research in Oceanside, California. Chugey specializes in pelagic fish biology and is especially interested in sustainable domestic fisheries. His laboratory focuses primarily on pelagic fish movement patterns and how they can be used to better understand regional fisheries. He holds an M.A. in Biology from California State University, Fullerton, and a Ph.D. in Marine Biology from Scripps Institution of Oceanography, University of California, San Diego.

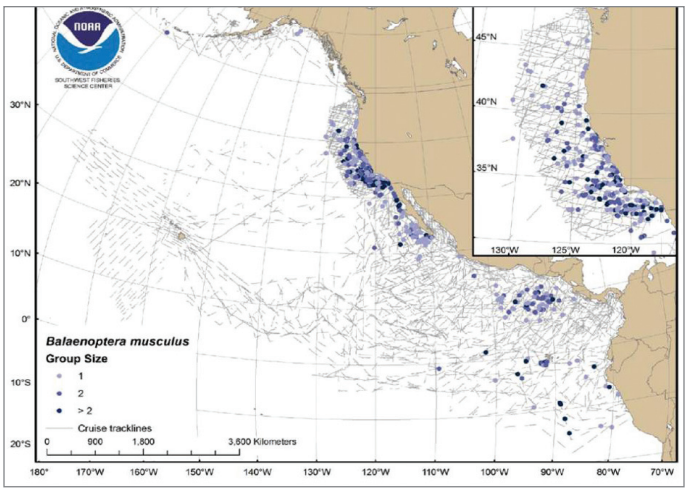
Dr. Heidi Dewar is a fisheries research biologist at the NMFS Southwest Fisheries Science Center in the Fisheries Resources Division. After receiving her Ph.D. at Scripps Institute of Oceanography on tuna physiology, she has worked on the development and application of tools that allow us to ask more complex questions about fish in their natural environment. Her research interests center on the physiological ecology of large pelagic fish including tuna, sharks, and billfish. In recent years, she has used a range of electronic tagging technology to document movements and behaviors that are then linked to oceanography to understand patterns.

Synthesizing Protected Species Data: Tools to estimate density and their application

Jessica V. Redfern, NMFS, Southwest Fisheries Science Center

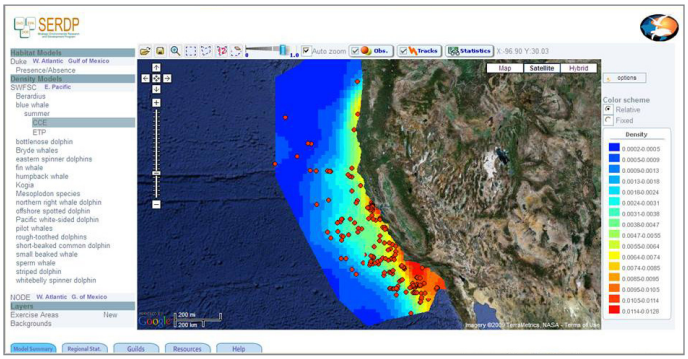
The ESA and MMPA require federal agencies to coordinate with users of the marine environment to assess the potential impact of their activities. The problem with estimating impacts on protected species is that the number of individuals in a particular area is frequently either unavailable or is summarized for a much larger geographic region. To facilitate obtaining the best possible estimates, the NMFS SWFSC has been working on developing tools to estimate cetacean densities in any user-defined region.

The SWFSC has been conducting cetacean and ecosystem assessments in eastern Pacific waters for over 20 years. During this time, 16 ship surveys have been conducted, comprising over 400,000 linear kilometers of survey transects, over 17,000 cetacean sightings, and ecosystem data including physical oceanography, midtrophic species, seabird species, and other apex predators. These data were used to develop habitat models for 12 cetacean species in the California Current ecosystem.



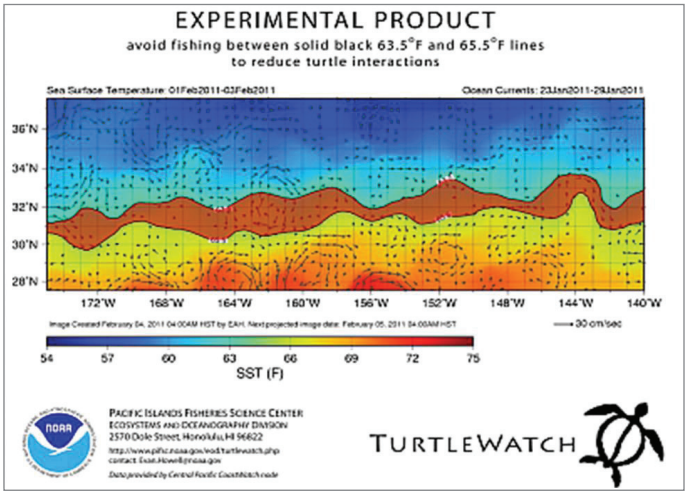
Record of blue whale sightings during NOAA ship surveys.

Many components of habitat modeling were explored to obtain the best possible models: model framework (e.g., general linear versus general additive models), sources of habitat data (e.g., remotely sensed versus in situ oceanographic data), the error structure of the model (e.g., Poisson versus quasi-likelihood), and model selection (e.g., Akaike information criterion and cross validation). The models were also validated using a novel data set. The models have been published in a number of peer-reviewed papers and represent the best available science for estimating the number of cetaceans using any user-defined region along the U.S. west coast. The densities predicted by the models have been made available online. At this web site, users may obtain estimates of cetacean density and the associated variance in their region of interest (see Appendix C for the link).



User interface of the marine animal model mapper based on density estimation models developed by Southwest Fisheries Science Center scientists.

The NMFS SWFSC is also working to estimate seabird density and understand sea turtle habitats. The NMFS Pacific Islands Fisheries Science Center (PIFSC) developed a tool (i.e., *Turtlewatch*) to help reduce inadvertent interactions between Hawaii-based longline fishing vessels and loggerhead turtles. This tool is based on the preferred thermal habitat of loggerhead turtles (see Appendix C for link). In partnership with the PIFSC, the SWFSC is exploring the possibility of developing a similar tool for leatherback sea turtles. Habitat drivers for leatherbacks may include sea surface temperature, productivity, and jellyfish abundance.



TurtleWatch is a tool for identifying areas with a high potential for sea turtle interactions. It is based on the strong relationship between sea surface temperature and incidental catch of loggerhead sea turtles interactions.

Selectivity of the U.S. West Coast Swordfish Fishery

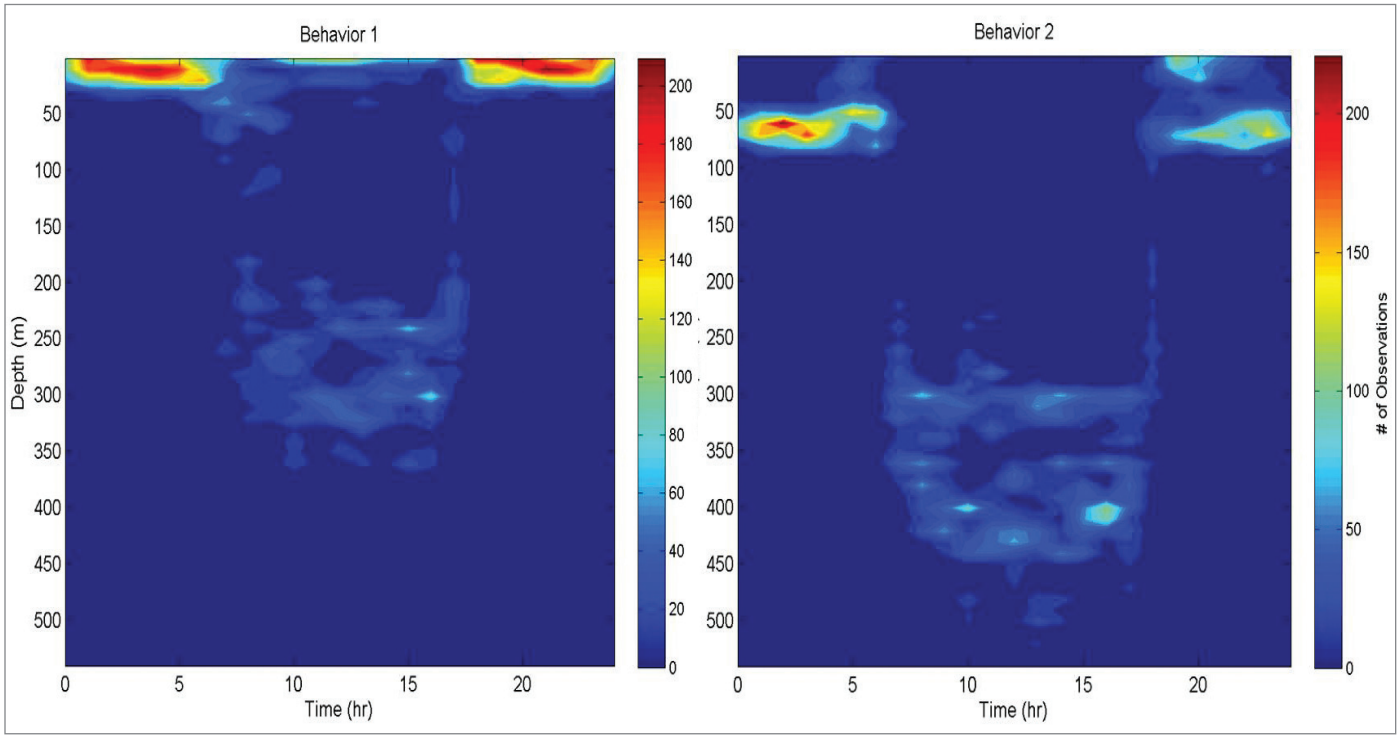
Chugey Sepulveda, Pfleger Institute of Environmental Research

The Pfleger Institute of Environmental Research (PIER) is dedicated to the advancement of sustainable fisheries management through applied field research and public education. PIER research has focused on the movements of swordfish in the Southern California Bight in an attempt to identify times and depths that swordfish segregate from other species. The findings from these studies are now being used to develop and test more selective types of fishing gear and methods that avoid protected and other bycatch species. Recently, PIER began experiments to test the efficacy of deep-set buoy gear to catch swordfish off of southern California.

Because of the high selectivity of harpoon fishing, PIER researchers recently examined the vertical distribution of swordfish to determine the factors that influence their basking rates, and whether there are specific times in which basking events are more prevalent. From these studies it was found that basking only represented about 8 percent of the depth records during the day and that the average bask duration was about 17 minutes. However, in some cases, longer basking periods were observed as well as extended periods (up to 2 weeks) with no daytime basking activity.

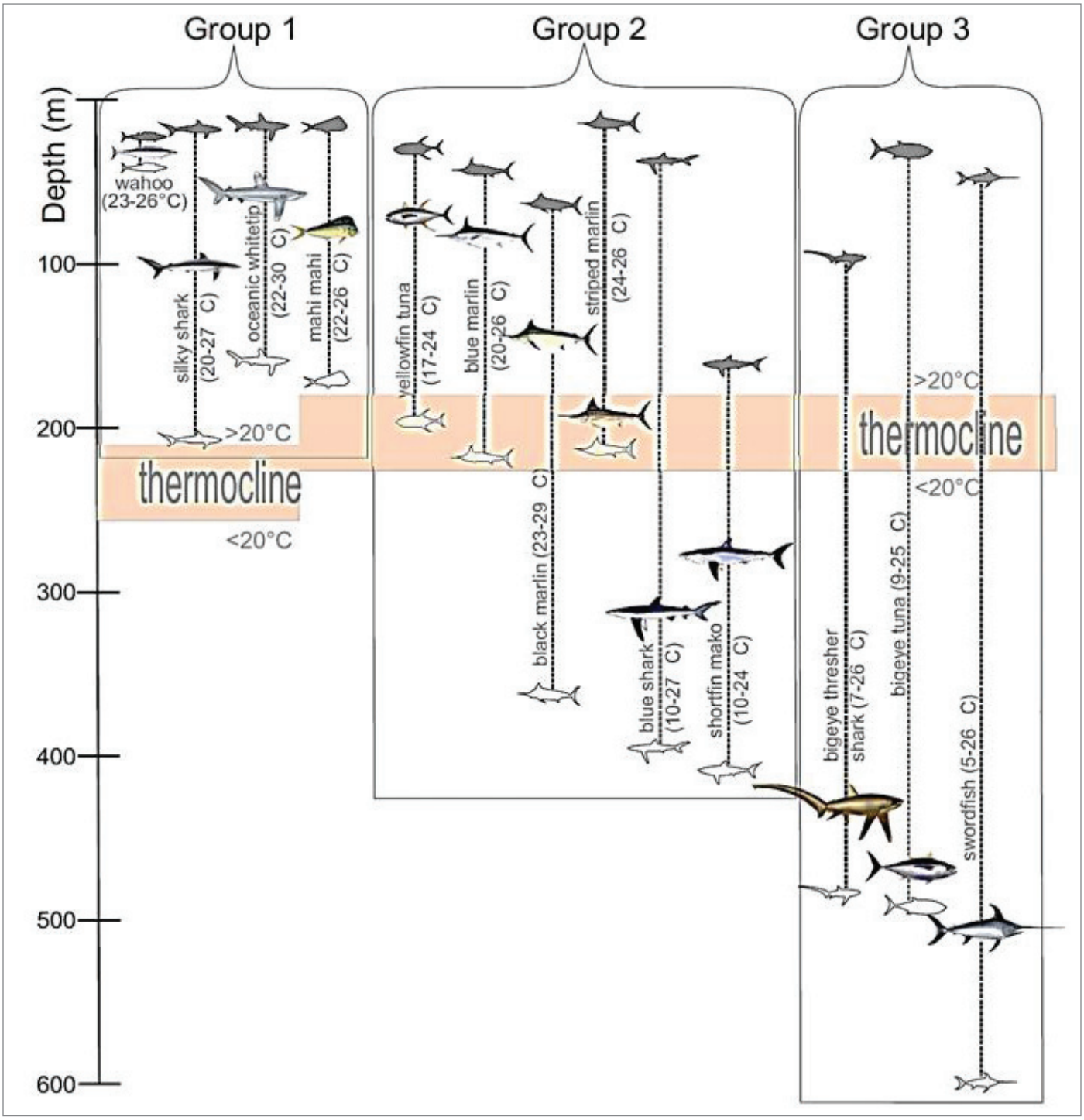
PIER swordfish movement studies have also been used to assess DGN fishing with regards to net depth and the targeting of swordfish. To reduce cetacean interactions, a minimum of 36 feet (~11 meters) subsurface net submersion requirements were established for DGN fishing practices in 1997. From the movement studies it was found that at night, swordfish spent 53 percent of the time above the minimum suspender length. Further increases in net depth decreased catch significantly. When coupled with movement studies for other species (i.e., secondary targets), it is evident that the deeper the nets are set, the less likely they are to catch both swordfish and other marketable species.

In the summer and fall of 2011, PIER researchers trialed the use of deep-set buoy gear off the California coast to test the efficacy of targeting swordfish at significant depth (300-500m) during the day. Because few bycatch species of the swordfish fishery have the



Depth distribution of swordfish plotted over a 24 hour period. Left panel represents typical diurnal behavior with periodic basking during the day. Right panel shows a similar diurnal distribution with no basking activity.

capacity to spend extended periods at depth, the PIER team proposed that deep-set buoy gear may prove to be highly selective in targeting swordfish in southern California. Initial development and trials of the experimental gear have proven to be successful in selectively targeting swordfish and avoiding bycatch species of concern.

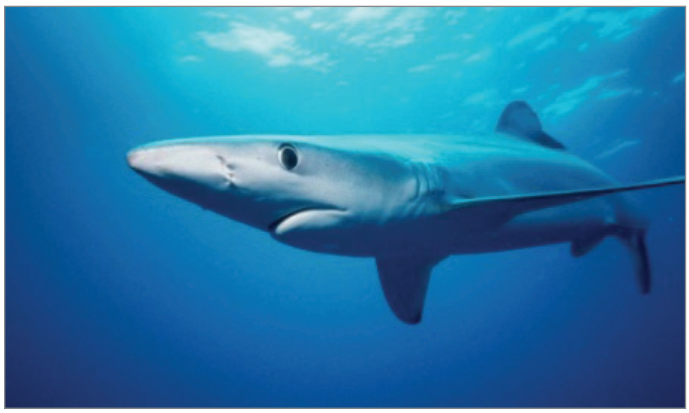


Vertical distribution of highly migratory species adopted from Bernal et al., 2009.

Shark Bycatch in the U.S. West Coast Swordfish Fisheries

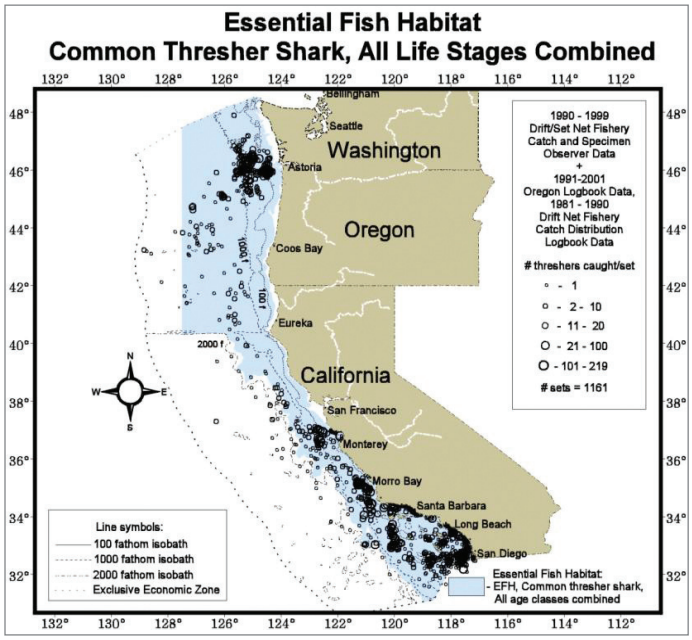
Suzanne Kohin, NMFS, Southwest Fisheries Science Center

Monitoring and ensuring sustainable levels for shark populations is an integral part of managing the swordfish fishery. For those fishing with DGN gear, common thresher shark (*Alopias vulpinus*) is a secondary target species, caught along with swordfish; shortfin mako shark (*Isurus oxyrinchus*) is caught incidentally and landed; blue shark (*Prionace glauca*) is bycatch and is discarded. There is significant bycatch of blue shark in the shallow-set pelagic longline fishery that operates off Hawaii. The harpoon fishery is highly selective and rarely catches a mako or thresher shark. Since 2000, annual landings of HMS shark species by harpoon gear have averaged about one round mt.



Blue shark. Photo by Mark Conlin.

U.S. west coast mako and thresher shark harvests are considered sustainable and the North Pacific blue shark population is above maximum sustainable yield, based on recent assessments, fishery data, and trend analyses. To ensure their populations remain sustainable, management measures are in place to minimize shark bycatch in the swordfish fishery. For instance, to protect thresher sharks, each year from May 1 through August 15 DGN fishing is not permitted within 75 miles of the west coast. Washington banned DGN fishing in its state waters. Oregon banned the targeting of thresher sharks, which effectively shut down the DGN fishery in its state waters as well. While the catch of blue shark is significant in the shallow-set longline fishery off of Hawaii, the catch of mako shark is low and common threshers are rarely caught. The Hawaii fishery currently operates under set limits, circle hook, and mackerel bait requirements. There is no shallow-set longline fishery off of California, as it was closed in 2004.



Essential fish habitat of common thresher shark, all life stages.

The trends in catch and nominal catch per unit effort for shortfin mako have been stable in the west coast DGN fishery. A precautionary harvest guideline based on an estimated local optimal yield for shortfin mako was established at 150 mt. The precautionary harvest guideline established for thresher shark is 340 mt, which is set 110 mt below an estimated local maximum sustainable yield to account for the vulnerability of pelagic sharks due to life history characteristics and catch by foreign fishing fleets. Estimated biomass of blue sharks in the north central Pacific declined in the late 1970s-80s, but appears to have recovered to early 1970s levels with current fishing effort lower than effort at maximum sustainable yield.

Continued research on gear and bait types and shark species associations with environmental features is needed to minimize bycatch and increase selectivity in the swordfish fishery. Researchers question if bait type may be more important to avoiding blue sharks than hook changes because catch rates were higher with squid bait, and the use of circle hooks had no consistent effect on catch rates. Additionally, examination of fine scale movement patterns of sharks may reveal important information about their habitat use so they can be spatially differentiated from swordfish.

Overview of the 2008 SLUTH Workshop

Heidi Dewar, NMFS, Southwest Fisheries Science Center

The Swordfish and Leatherback Use of Temperate Habitat (SLUTH) Workshop was held on May 28-29, 2008, at the University of California, San Diego, Scripps Institution of Oceanography. The purpose was to share the current state of knowledge among stakeholders and identify data gaps associated with developing a holistic approach to sea turtle conservation and a more dynamic approach to management for the west coast swordfish fishery (i.e., not large, static time-area closures).

The leatherback sea turtle is listed as endangered under the ESA in the Pacific Ocean. Due to the extensive migratory nature and complex life history of leatherback sea turtles, their population recovery requires a coordinated international effort that will boost reproductive output on nesting beaches while reducing bycatch of juveniles and adults in coastal and pelagic fisheries throughout their range. NMFS implemented the PCLA in 2001 to assist the U.S. west coast swordfish fishery in avoiding interactions with leatherbacks, but this closure contributed to a decline in fishing vessels, landings, and revenue. To discuss management and conservation issues with a range of stakeholders, NMFS convened the SLUTH workshop in 2008. There were approximately 40 participants, including scientists from the United States and Mexico; DGN, longline and harpoon fishermen; seafood processors; importers/exporters; and state and federal fisheries managers. Participants discussed the need for a strong, well-regulated U.S. swordfish fishery coupled with a broad cooperative research program to help inform management and a more holistic approach to sea turtle conservation that addresses multiple sources of mortality.

Leatherback sea turtle. Photo by Scott Benson.

Participants discussed the following topics:

- Science relevant to leatherback and swordfish movement patterns, habitat utilization, trophic dynamics, population status, and management concerns.
- Approaches to promote a sustainable and an economically viable west coast-based swordfish fishery while minimizing impacts on leatherback turtles and other non-target species.
- Data gaps, available tools, and practical next steps towards the development of a more holistic approach to sea turtle conservation, as well as further exploration of fishery management options.

Two themes that surfaced throughout the workshop were the concepts of an "ecological footprint" and "transfer effects". Participants discussed the ecological footprint as related to the bycatch and mortality of leatherback turtles, primarily, in the swordfish fisheries. Transfer effects relate to the shift of bycatch to foreign fleets when the supply of domestic swordfish decreases. Foreign fleets tend to be less strictly regulated and likely take more turtles per unit effort.

Scientists and fishermen also spent considerable time discussing the behaviors and shared habitat of swordfish and sea turtles. Both agreed that these species may use separate habitats and that a better understanding of those differences may offer an opportunity to develop an adaptive management strategy to provide for more fishing opportunity while minimizing interactions. Participants strongly supported continued research efforts to determine fine-scale habitat use of both species to identify areas of least overlap. Since the SLUTH workshop, many of the participating researchers and government staff, primarily, have come together for focused discussions on follow-up research projects.

Key Recommendations from the SLUTH Workshop:

Including some research updates from the SWFSC Fisheries Resources Division (FRD)

- A cooperative research program to obtain data needed to develop a model-based adaptive management strategy, such as temporal and spatial patterns in habitat use of both swordfish and leatherback sea turtles with an emphasis on the influence of oceanography.

  Update:

  1. FRD and the SWFSC PRD conducted a joint cruise in the PLCA to simultaneously characterize the habitats of swordfish and leatherbacks.
  2. FRD tested a new satellite tag design that will improve habitat characterization for swordfish. The next step is to deploy these tags north of Point Conception.
  3. PRD and FRD have been working together on modeling approaches to identify what factors most influence the distribution of swordfish and leatherbacks.

- Evaluate and compare the economic viability and ecological footprint, or bycatch rate, of DGN and shallow-set longline fishing for turtles and other species, including sharks.
- Test the effectiveness of gear modifications to DGN and shallow-set longline gear to reduce bycatch of both sea turtles and other non-marketable finfish species if possible.

  Update:

  During annual shark surveys, FRD tested shark deterrents to reduce shark bycatch on longline gear.

- Conduct economic studies to: 1) determine if there were transfer effects when the west coast based fishery was reduced; 2) estimate the cost of management measures in relation to transfer effects; 3) quantify comparative viability of harpoon, DGN, and longline fleets; and 4) identify and evaluate the most efficient international management measures to promote conservation while supporting a viable U.S. fishery.
- Evaluate conservation investments by which producers and consumers inflicting sea turtle mortality can improve the status of the species. Protections at sea turtle nesting sites and the reduction of bycatch in coastal, small-scale, and artisanal fisheries provide natural focal points for conservation biodiversity investments.
- Expand the education and outreach effort to improve the scientific quality of the public policy debate and to engage broad stakeholder participation.

Session Summary

Key points made by presenters in this session included:

- The NMFS SWFSC has developed a software tool to estimate cetacean density in any user-defined region of the California Current. Estimation of the number of protected species impacted by proposed marine activities, such as adopting new fishing regulations, conducting offshore drilling, or designating commercial shipping lanes, is required by the ESA and MMPA.
- Research on swordfish behavior is providing insights into swordfish catchability and different fishing gear types that may prove to be more selective. With this information, NMFS aims to explore the possibility of predicting leatherback sea turtle use of habitat. These predictions could potentially be used to help reduce leatherback sea turtle bycatch similar to what has been accomplished with loggerhead sea turtles in the northern Pacific Ocean.
- Because of the limited time swordfish spend basking at the ocean surface (~8 percent), coupled with the weather constraints associated with the harpoon fishery, it is likely unfeasible for the harpoon fishery alone to fully meet west coast swordfish demands.
- Additional research on other low-impact gear types (e.g., deep-set buoy gear) may provide alternative options for increasing fishing opportunities that have minimal interactions with non-target species.
- Incidental catch of sharks in the swordfish fishery varies by fishing gear and methods. Modifications in the DGN gear, such as using extenders and areas restrictions, have helped to reduce shark bycatch. The DGN fleet incidentally catches primarily common thresher, shortfin mako, and blue sharks; shallow set longlines tend to catch shortfin mako and blue sharks. Thresher and shortfin mako sharks are landed. Overall, thresher, shortfin mako, and blue shark catch levels for the U.S. west coast swordfish fishery are considered sustainable.
- The 2008 NMFS SLUTH workshop identified the need to further examine potential separations in the use of habitat (e.g., depth) by swordfish and leatherback sea turtles, explore possibilities for dynamic management models (e.g., *Turtlewatch*), and better understand transfer effects associated with U.S. west coast regulations. This information would offer opportunities for creating a holistic plan for protecting leatherback turtles while achieving a more sustainable swordfish fishery.