WORKSHOP REPORT (DRAFT)

SWORDFISH AND LEATHERBACK USE OF TEMPERATE HABITAT (SLUTH)

CONVENED BY: National Marine Fisheries Service Southwest Region and Southwest Fisheries Science Center-La Jolla

DATE: May 28-29, 2008

LOCATION: UC San Diego's Scripps Institution of Oceanography

AUTHORS IN ALPHABETICAL ORDER: Scott Benson, Heidi Dewar, Peter Dutton, Christina Fahy, Craig Heberer, Dale Squires and Stephen Stohs

EDITED BY: Heidi Dewar

EXECUTIVE SUMMARY

The leatherback turtle is endangered in the Pacific Ocean and concern about their persistence has increased as a result of declines in nesting populations over the last three decades. Due to the extensive migratory nature and complex life history of this trans-boundary species, population recovery requires a coordinated international effort that will boost reproductive output on nesting beaches while ensuring maximum survival of juveniles and adults in the ocean. To reduce adult mortality in shallow set longline (SSLL) and drift gillnet (DGN) fisheries, the U.S. has implemented a series of measures restricting fishing activity. The implementation of these measures has come at great economic cost to the U.S. fishing industry. For example, there has been a 50 percent decline in both the number of vessels and annual revenue for the west coast swordfish DGN fishery. The conservation benefits of the U.S. fishery management actions are uncertain and may have unintentionally led to a net increase in bycatch in the Pacific due to the potential transfer of fishing effort to foreign fleets, many of which have not instituted conservation measures to protect leatherbacks. Although no analysis has been conducted for west coast swordfish fisheries, two recent papers suggest that there may have been a market transfer when the Hawaii-based SSLL was closed in 2001. Ultimately, these U.S. fishery management actions by themselves will likely fail to reverse the leatherback population declines, since the animals that forage in waters fished by the U.S. fleet represent a small portion of the whole population, and significant threats remain at the nesting sites and adjacent waters in the western Pacific and South China Sea. NMFS is interested in exploring fishery options that would help recover leatherback populations and benefit the U.S. consumer and U.S. fishers. The goals would be 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 turtle conservation that addresses multiple sources of mortality.

An information exchange workshop entitled Swordfish and Leatherback Use of Temperate Habitat (SLUTH) was held May 28-29, 2008 at UC San Diego's Scripps Institution of Oceanography. The purpose of the workshop was to explore a more holistic approach to turtle conservation and to determine if a more adaptive management strategy (i.e., management not based upon large, static time/area closures) for west coast swordfish fisheries is feasible. The basic objectives of this first workshop were as follows:

- Review current science relevant to leatherback and swordfish movement patterns, habitat utilization, trophic dynamics, population status, and management concerns.
- Develop approaches to promote sustainable and economically viable west coast-based U.S. swordfish fisheries while minimizing the impacts on leatherback turtles and other non-target species.
- Develop an advisory team to help guide research, monitoring, and conservation efforts composed of fishermen, scientists, managers, economists, and non-governmental organizations (NGOs).
- Provide a forum to share views, express concerns, and develop future plans.
- Identify data gaps, available tools and practical next steps towards the development of a more holistic approach to turtle conservation, and further develop fishery management options.

The workshop was sponsored by the NOAA Fisheries Southwest Region (SWR) and the Southwest Fisheries Science Center-La Jolla (SWFSC), with over 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 (Appendix A). Invited representatives from a number of NGOs could not attend due to scheduling conflicts, but expressed an interest in participating in future efforts. The participation of such a diverse group is a promising sign of broad stakeholder support. The success of future efforts will rely heavily on the continued participation of this group.

Two recurring themes that surfaced throughout the workshop were the concepts of an "ecological footprint" and a "transfer effect." The ecological footprint refers, in this context, to the bycatch and mortality of leatherbacks in the swordfish fisheries, however in later discussions all species taken are considered. Transfer effects relate to the shift of bycatch to foreign fleets as the supply of swordfish shifts away from domestic producers. Foreign fleets tend to be less strictly regulated and likely take more turtles per unit effort. Recent analyses suggest a transfer effect may have occurred when the Hawaii-based SSLL fishery was closed in 2001 due to concerns about ESA-listed sea turtles. The possibility that the DGN time/area closure caused a similar transfer effect is listed as a high priority data gap that needs to be further explored.

In addition to the reoccurring themes mentioned above, scientists and fishermen spent considerable time discussing the habits and shared habitat of swordfish and sea turtles. Both fishermen and scientists agreed that there is potential separation of habitat used by swordfish and leatherback turtles that may offer an opportunity to develop an adaptive management strategy to support fishing while minimizing leatherback interactions. Participants strongly supported the development of new research efforts to determine fine-scale habitat use of both species, representing a first step toward identifying dynamic areas of least overlap between the species.

Finally, there was considerable discussion about Pacific-wide leatherback sea turtle conservation efforts and the economic and political landscapes.

The group recommended the following actions:

- Initiate a cooperative research program to obtain the data needed to develop a model-based adaptive management strategy. This includes defining temporal and spatial patterns in habitat use of both swordfish and leatherback sea turtles with an emphasis on the influence of oceanography.
- Evaluate and compare the economic viability and ecological footprint, or bycatch rate, of DGN and SSLL fisheries for turtles and other species, including sharks.
- Test the effectiveness of gear modifications to DGN and SSLL gear to reduce bycatch of both sea turtles and other nonmarketable finfish species if possible.
- Conduct economic studies to: 1) determine if there were transfer effects when the California-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. This effort would include dissemination of current scientific knowledge on leatherback turtles and swordfish, promotion of a more holistic approach to leatherback conservation, and discussion of the concept of the ecological footprint and transfer effects.

In a larger context, this workshop supported the mandates of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA) and the Fishery Management Plan for U.S. west coast Fisheries for Highly Migratory Species (HMS FMP). The primary intent of the MSRA is to promote the sustainability of fishery resources off the United States to contribute to the national food supply, economy, and health. The HMS FMP embodies similar objectives in support of domestic U.S. west coast HMS fisheries. National standards contained in the MSRA necessitate that these fishery conservation and management objectives be met while protecting the environment through reducing or minimizing bycatch. U.S. commercial fisheries that interact with marine species protected or listed under the Marine Mammal Protection Act (MMPA) or the Endangered Species Act (ESA) may be managed further, often through regulations, to minimize protected species bycatch or associated mortality (Helvey and Fahy *in review)*.

Report Content and Format

This report provides background information presented by invited speakers, as well as summaries of the discussions of the workshop and breakout sessions. This report will serve as a catalyst to develop and fund a comprehensive multidisciplinary research program aimed at providing managers and policy makers with information necessary to sustainably conserve and manage the west coast highly migratory species fisheries consistent with the mandates of the MSRA, the MMPA, and the ESA. The creation of a working group across broad stakeholders, from fishermen to NGOs, is critical to this process.

TABLE OF CONTENTS

BACKGROUND:

I. The History of the Swordfish Fishery off the U.S. West Coast

Off the U.S. West Coast, the harvest of swordfish for consumption predates European settlement. From at least the 1st century AD, the Chumash tribe in California's Santa Barbara region caught swordfish with harpoons thrown from plank canoes (Davenport et al. 1993). This method depended on a behavioral trait called "finning" where swordfish periodically bask at the surface, a behavior that can easily be sighted on clear, relatively windless days. California's modern harpoon fishery began in the early 1900s (Coan et al. 1998) and grew in response to increased consumer demand for swordfish (Sakagawa 1989).

Harpoon fishing remained the only legal means of harvesting swordfish in U.S. waters until the late 1970s when a few west-coast-based vessels began targeting common thresher sharks using large mesh drift gillnets. Swordfish and shortfin mako sharks were important components of the catch (Hanan et al. 1993) and it soon became apparent that the DGN fishery was more cost effective and yielded greater catches of swordfish than the harpoon fishery. Swordfish was also worth nearly four times the dockside value of sharks (Holts 1988), and by the early 1980s, swordfish became the primary target species for the DGN fleet. Due to the greater economic efficiency of the DGN gear and the harpoon fishery's dependency on sighting swordfish at the surface (Sakagawa 1989; Coan et al. 1998), the DGN fishery evolved as the primary means of harvesting swordfish within the U.S. west coast exclusive economic zone (EEZ) since the early 1990s (PFMC 2007). This efficiency, however, came at a cost in terms of increased bycatch interactions relative to harpoon gear, with marine mammals, sea turtles, and managed and monitored finfish species such as tunas and sharks.

While not allowed in the west coast U.S. EEZ, the primary gear type used worldwide to harvest swordfish is pelagic longline (Watson and Kerstetter 2006). The gear is typically set at night in the upper 100 meters of the water column (i.e., "shallow-set longline" or SSLL) to coincide with the nocturnal movements of swordfish into near surface waters. First attempts at exploring the use of longlines in California occurred in the late 1960s but proved commercially unsuccessful due to large blue shark bycatch (Kato 1969). Then, during the 1991-1992 fishing season, three U.S. flagged high seas[1] longline vessels relocated from the Gulf of Mexico to the West Coast and based their operations out of California. By 1994, the number of vessels grew to 31 (Vojkovich and Barsky 1998). Beginning in 1995, the majority of these longline vessels began following the seasonal east-west movements of swordfish in the North Pacific. In the spring and summer longline vessels operated out of Hawaii and during the fall and winter they operated outside the west coast EEZ (NMFS 2004), with some annual shifts in effort associated with fisheries regulations. The west coast SSLL fishery continued until 2004 when the Pacific Fishery Management Council's (Pacific Council) HMS FMP was adopted and submitted to the National Marine Fisheries Service (NMFS) for review and approval. Due to concerns about the potential for excessive take of loggerhead sea turtles, the SSLL was not approved and regulations issued under the ESA closed the SSLL fishery operating out of California and fishing east of 150^{o} W longitude.

[1] Beyond the U.S. 200 nautical mile Exclusive Economic Zone.

At that time, the California based SSLL fishery did not include gear and bait modifications that had recently been developed to reduce sea turtle bycatch. A shift from J-hooks and squid bait to circle hooks and mackerel-type bait has been shown to reduce sea turtle bycatch and mortality (Watson et al. 2005; Gilman et al. 2007). At about the same time, the Hawaii-based SSLL fishery (which had been closed in 2001) was re-opened after these gear and bait modifications were adopted, including the use of 18/0 circle hooks with a 10^{o} offset. In addition, a maximum annual limit on the number of turtle interactions was established and 100% observer coverage was initiated.

II. Status of Western Pacific Leatherbacks

While the oceanic waters off the U.S. West Coast are considered a productive area for swordfish, they are also considered an important foraging area for ESA-listed leatherback sea turtles and an occasional foraging area for loggerhead sea turtles. Analyses of genetic data and satellite tracking of leatherbacks by the SWFSC indicate that these animals originate from nesting beaches in the western Pacific (e.g., Indonesia and Solomon Islands) (Benson et al. 2007a). These turtles are genetically distinct from turtles nesting in the eastern Pacific that forage in the southeastern Pacific (Dutton et al. 2007). In the western Pacific, there are an estimated 1,100 to 1,800 females nesting each year at 28 nesting sites, and leatherbacks typically nest every other year. The overall estimate of nesting females in this area is approximately 2,700 to 4,500 individuals, although these are considered rough estimates, since they are derived from nest counts (Dutton et al. 2007). While this subpopulation is not experiencing the dramatic declines that are evident in the eastern Pacific subpopulation, there have been significant declines at long-term monitored beaches since the 1980s (Hitipeuw et al. 2007).

III. Regulatory Controls for Reducing Sea Turtle Bycatch in the DGN Fishery

In 2000, NMFS conducted an ESA Section 7 consultation on the issuance of a permit to take endangered and threatened marine mammals in the west coast (California/Oregon) DGN fishery. The resulting biological opinion concluded that operations of the DGN fishery were likely to jeopardize the continued existence of leatherback and loggerhead sea turtles. To reduce leatherback turtle take in the DGN fishery by an estimated 78 percent, NMFS implemented a time/area closure based upon where the majority of leatherback takes had been observed (NMFS 2001a). The Pacific Leatherback Turtle Conservation Area (PLCA) was established and prohibited DGN fishing from Point Conception, California to mid-Oregon and west to 129° W longitude from August 15 to November 15 (Figure 1)[2]. There have been no observed takes of leatherbacks in the DGN fishery since the PLCA was established.

[2] In 2003 NMFS issued a regulation under the ESA to protect loggerhead sea turtles which prohibits the use of DGN gear in the southern California Bight during June, July, and August when El Niño or El Niño-like conditions exist in the area. This closure has not been triggered.

Figure 1. The Pacific Leatherback Turtle Conservation Area

With historical DGN fishing grounds reduced by approximately 200,000 square miles, it is not surprising that the number of vessels participating in the swordfish fishery has declined from 69 in 2001 to 38 in 2006 (PFMC 2007). The establishment of the PLCA also shifted the fishery and supporting infrastructure to southern California ports. The economic impact of the 2001 closure to the domestic swordfish industry has been substantial (Gjertsen *in press*): revenue from the DGN fishery declined by 60 percent, from $5.4 to $2.3 million annually. This does not include loss to supporting infrastructure and other indirect fishery derived revenues.

IV. Efforts to Reduce Bycatch

In addition to the regulatory controls implemented over the last 10 years, a number of projects have been initiated to examine gear alternatives and modifications to reduce bycatch with efforts focusing primarily on reducing marine mammal take. In 1996, the Pacific Offshore Cetacean Take Reduction Team (POCTRT) was formed to produce a plan to reduce marine mammal bycatch in the DGN fishery for swordfish. For various reasons, harpoons were not considered a viable substitute for the DGN fishery. Longlines were also not considered an option at the time because they were not an authorized gear type within the U.S. EEZ. Since then, the Pacific Council adopted the HMS FMP authorizing pelagic longlines as an HMS gear, although longline fishing for HMS within the EEZ is currently not permitted under the HMS FMP. Gear modifications in the DGN fishery, including attaching of pingers to nets as an acoustic deterrence, and the use of net extenders to allow marine mammals to pass over the nets, have successfully reduced overall cetacean take. However, DGN gear modifications are not typically considered to be effective at reducing sea turtle bycatch (Harrington et al. 2005; McShane et al. 2007).

Though longlining has long been synonymous with bycatch concerns, gear modifications to traditional longline gear for reducing turtle bycatch have been successfully implemented in a number of fisheries. As mentioned above, a shift from J-hooks to circle hooks and from squid bait to mackerel-type bait resulted in a dramatic decline in turtle takes in both the Atlantic and Pacific Oceans (Watson et al. 2005; Gilman et al. 2007). In fact, the SSLL fishery operating out of Hawaii was recently endorsed by the Monterey Bay Aquarium's Seafood Watch Program[3] in recognition of the strength of management and conservation measures implemented to minimize bycatch. Given the improvements to longline gear, an Exempted Fishing Permit (EFP) application was submitted to the Pacific Council and NMFS for a single longline vessel to explore the economic viability of using SSLL gear to target swordfish in an area from 50 to 200 nm off the coast of California. The EFP application was met with considerable public resistance despite NMFS receiving a recommendation for approval by the Pacific Council. However, due to administrative delays during a California Zone Management Act consistency determination review by the California Coastal Commission (CCC), the applicant withdrew the EFP late in 2007. In 2008, the permit application was resubmitted to the Pacific Council and is currently under consideration by NMFS. This time the CCC was denied review authorization by NOAA's Office of Ocean and Coastal Resource Management for its failure to demonstrate that the EFP would have reasonably foreseeable coastal effects. Data generated from the EFP activity, if it proceeds, would support the goals of the SLUTH program.

V. Ecological Footprint and Transfer Effects

The curtailment of U.S. domestic fisheries for swordfish may have had unintended consequences with regard to reducing sea turtle mortality due to a shift in supply to foreign fleets. U.S. landings of swordfish show a general pattern of decline from the early 1990s through the 2000s. Landings in 2006 of 2,711 metric tons (mt) were only 25% of the peak recorded in 1993 (U.S. Dept of Commerce Com. Fish. Land. 2008). The share of U.S. demand provided by landings into the U.S. West Coast and Hawaii fisheries has dropped from an average of 20% between 1989 and 2000 to seven percent between 2001 and 2006 (U.S. Dept of Commerce U.S. Foreign Trade 2008). With a relatively larger reduction in domestic supply than the reduction in domestic demand, U.S. swordfish imports have increased. In 1993 imports accounted for 43% of U.S. demand by weight, by 2006 this had increased to 88% with a value of $76 million. Singapore, Panama, Canada, Costa Rica, Mexico, and Chile were the dominant foreign suppliers (U.S. Dept of Commerce U.S. Foreign Trade 2008).

Some of the foreign fleets supplying swordfish to U.S. markets are unregulated and unobserved and likely have a significant bycatch of leatherbacks. Many of these foreign fleets continue to use J-hooks and squid bait. Circle hooks and mackerel-type bait are now required in most U.S. fisheries. In addition, these foreign fleets may have increased their effort in waters previously occupied by U.S. fleets. In 2001, NMFS predicted that there might be negative transfer effects to turtles if the Hawaii SSLL fishery closed (NMFS 2001b). Two recent studies have suggested that the Hawaii-based longline fishery closure did lead to an increase in the number of total sea turtle interactions as a result of this market displacement (Samiento 2006, Rausser et al. 2008), although no similar study has been conducted for the U.S. West Coast and additional research is needed. Any transfer effects are a part of the ecological "footprint" associated with closures or reductions in landings by U.S. domestic fisheries that should ideally be taken into account when making management decisions. Additional factors include the discarded bycatch of other non-target species and the environmental footprint of transporting fish from distant markets. The

[3] http://www.montereybayaquarium.org/cr/seafoodwatch.aspx

continuing decline in swordfish production by U.S. west coast fishermen plus the persistent U.S. demand suggests that reliance on foreign imports will persist. Encouraging the use of modified gear in U.S. fisheries, which result in relatively low bycatch and mortality, could benefit the impacted species of sea turtles particularly if well managed fisheries are coupled with a broad suite of multilateral conservation and education measures (Dutton and Squires 2008; Steering Committee, Bellagio 2008). In order to encourage a more holistic management regime, the United States must have active fisheries. In addition, U.S. fishermen have shown themselves to be global leaders in designing and implementing effective gear modifications to reduce bycatch.

PRESENTATIONS:

Briefly, presentations covered issues relevant to biology, habitat, management, and fisheries interactions of both swordfish and leatherback sea turtles (Appendix B). The first talks covered the fisheries, status of stocks, and history of management in both the United States and Mexico. Both countries have been fishing swordfish in the California Current for more than 20 years, although currently the primary gear types differ in the two countries. Mexican swordfish fisheries use SSLL while U.S. fisheries use DGN gear. While stock structure remains to be resolved, stock status appears to be healthy in the eastern North Pacific based on the last analyses conducted in 2004. In the United States, the temporal and spatial patterns of swordfish fisheries are now largely influenced by regulations implemented to reduce sea turtle take. In addition, increased fuel costs and fluctuating market dynamics are starting to negatively impact U.S. fishermen. Due in part to a reduction in overall fishing effort, the United States now imports a large volume of swordfish from countries, including Mexico, where fuel costs are substantially lower.

To study the movements and behaviors of swordfish and leatherback sea turtles, a number of scientists have been using electronic tags. Studies of swordfish have been conducted in the Southern California Bight where fish are tagged using a modified harpoon. Electronic tag data reveal that swordfish typically prefer deep, cold water during the day but then vertically migrate to the surface at night. Some days are punctuated by basking events, during which local harpooners are able to target swordfish. There are currently no data on the vertical and horizontal movements of swordfish north of Point Conception, where the majority of turtle interactions occurred in the DGN fishery prior to the establishment of the PLCA in 2001. Electronic tags have also provided considerable data on the large-scale migrations and behaviors of leatherbacks. These efforts were instrumental in documenting the migrations of leatherback sea turtles from Indonesia to the central California coast and are helping researchers understand how oceanography influences movements in the California Current region.

Understanding habitat use patterns of leatherback turtles may lead to adaptive management of the fishery. In the subtropical convergence zone in the central Pacific the “TurtleWatch” program developed by researchers at NOAA’s Pacific Island Fisheries Science Center uses a relatively simple environmental indicator (based on sea surface temperature and ocean currents) to define loggerhead sea turtle habitat (http://www.pifsc.noaa.gov/eod/turtlewatch.php). This information is updated in near-real time and is provided to fishermen so that they can avoid specific areas when setting and hauling gear. Similar options were discussed at this workshop for delineating leatherback sea turtle habitat in the California Current. Unfortunately, leatherback sea turtle habitat in the California Current is much harder to define. This is an extremely dynamic system with complex meso-scale features and seasonal upwelling. It is also not clear what influences the distribution of the leatherback turtles' preferred prey, the brown sea nettle (*Chrysaora fuscescens*), which are found in frontal areas also attractive to both leatherbacks and swordfish.

Members of industry also gave presentations and provided valuable input on the behaviors of swordfish and sea turtles, fishing techniques and gear, and the costs associated with certain management decisions, such as time/area closures and gear requirements. Economic concerns were the most prevalent topic from all parties. Drift gillnet fishermen noted that the bycatch mitigation measures, including increased mesh size and the addition of pingers, have successfully reduced the bycatch of protected species without impacting catch rates. They felt, however, that implementation of the PLCA put a lot of fishermen out of business, and with rising gas prices, more fishermen are likely to be pushed out of the industry. The processors indicated that a disruption in the supply of swordfish associated with regulations could negatively impact market demand for fresh local fish. There was some discussion about import tariffs to level the playing field with foreign fleets that tend to be subsidized. The fishermen were apprehensive about the effectiveness of leatherback sea turtle conservation measures. There was some concern that current regulations on the swordfish fishery are pushing fishing effort to other countries with less stringent regulations and higher takes of turtles, thus undermining conservation efforts. Industry participants also suggested a "levy" on fishermen that would support leatherback conservation in other areas where the impact per dollar invested would be greatest.

WORKING GROUP BREAK OUT SESSIONS:

Following the presentations, the participants separated into a series of working groups to discuss, among other things, options for filling in data gaps and research and monitoring needs that were identified during the preceding day and a half. The working groups were organized around three main functional areas: 1) Reducing Encounter Rates; 2) Economics; and 3) Management/Policy Issues.

I. Reducing Encounter Rates

Discussion on efforts to reduce encounter rates focused on: 1) obtaining a better understanding of the underlying factors contributing to bycatch interactions by gear type; and 2) identifying areas of minimal habitat overlap of swordfish and leatherbacks in time and space.

A. Predictive Modeling

To understand the temporal and spatial distributions of bycatch, researchers have used a variety of statistical techniques to quantify patterns. While understanding patterns in bycatch is important, it does not allow us to predict bycatch unless we assume that fishing effort and the distribution of the protected species are constant over time, which is seldom the case. To reliably predict the interactions between fishing operations and protected species, one needs to understand the spatial and temporal distributions of the target catch and the bycatch species. For example, the "TurtleWatch" program based out of Hawaii takes this approach (Howell et al. 2008). TurtleWatch is a mapping tool that helps fishers avoid loggerhead sea turtle habitat and illustrates the advantage of using information on fishing operations and protected species in building a management tool.

To develop predictive models, we treat the distribution of fishing gear and protected species as independent random variables. A variety of factors affect the distribution of fishing gear and protected species. For example, the distribution of protected species is affected by the distribution of prey species, which is determined by time, physical features such as currents, productivity, temperature, and other environmental variables. The distribution of fishing gear, on the other hand, is often affected by regulations and the distribution of target species. Consequently, given an environmental condition and existing regulatory restrictions, the distribution of protected species and fishing gear may be constructed. The probability of interaction between the turtles and gear can then be calculated and used to guide management decisions. To minimize the interactions between wildlife and fishing operations, decisions need to be made such that fishing is allowed in the temporal and spatial strata where the probability of the interactions is small and the fishery is economically viable.

While predictive modeling has proven to be a powerful tool in other systems, it requires detailed information on the habitat use of protected and target species (information on the target species is an important part of predicting the efficiency of the fishing fleet). What is needed is information on the influence of both fine- and meso-scale environmental conditions on both vertical and horizontal movements, as shifts in either could be exploited. For example, while both species are associated with frontal features, there is some suggestion that they are utilizing different parts of the front. Also, there is likely considerable separation in the depths utilized during the day, when swordfish feed on the deep scattering layer and turtles occur generally in the top 100 m of the water column.

B. Swordfish

i. Background

Swordfish support one of the largest U.S. HMS fisheries in the North Pacific and leatherback sea turtles have been taken in both the DGN and longline fisheries targeting them. Collecting data on the distribution and habitat of swordfish is critical to developing models to predict the temporal and spatial patterns in swordfish fisheries; however, model inputs for swordfish are incomplete due to data limitations. While a number of research programs have studied swordfish movements, behaviors, and habitat use in the Southern California Bight, no information is currently available north of Point Conception where the majority of leatherback sea turtle bycatch was documented for the DGN fishery prior to implementation of the PLCA time/area closure. Behavior in this region cannot be predicted using data currently available from other areas. The depths and temperatures swordfish encounter during both the day and night vary dramatically across locations and their behaviors appear to be linked to temperature profiles, bathymetry, light attenuation with depth, and oxygen concentrations (Dewar et al. *in prep*). Given the complexity of their behaviors and lack of information on their response to the regional oceanographic features, we cannot predict behaviors of swordfish off Central California. For data to be relevant to the fisheries off Central California, it must be collected from swordfish in this region.

ii. Data Gaps

1. Vertical and horizontal habitat use patterns of swordfish north of Point Conception.
2. The influence of oceanography on swordfish vertical and horizontal behavior north of Point Conception.
3. Factors affecting timing of arrival of swordfish on Central California fishing grounds.
4. Preferred prey of swordfish off Central California.

iii. Strategy

1. Conduct electronic tagging studies of swordfish off Central California and examine behaviors with respect to detailed oceanography for the region.

The most effective way to collect data on vertical movements will be through the use of electronic tags (pop-up satellite and archival). These devices have revolutionized the study of the biology of pelagic fish over the last decade (Arnold and Dewar 2001). Briefly, archival tags record highly detailed data but must be recovered when the fish is caught. The pop-up satellite tags on the other hand, record data until they release from the animal and upload their data to satellites. While the fish need not be recaptured, the data obtained are only summaries of all data collected. Both tags will record depth and temperature data and will allow us to resolve day/night differences. It is likely that the greatest habitat separation between swordfish and leatherbacks occurs during the day when swordfish are foraging in association with the deep scattering layer.

To develop statistically rigorous models, a large number of animals must be tagged. The optimal method to deploy tags would be to work with an experienced longliner on a chartered fishing vessel. Ideally the fishing boat would be equipped with a plank to allow for tagging of free-swimming fish. This would be the preferred option for any future large-scale tagging program. It occurred to the working group that a second option, which could be implemented within a few months at relatively little cost, was to longline from the NOAA Ship *David Starr Jordan* during the Leatherback Use of Temperate Habitat (LUTH) cruise planned for late summer (2008) off Central California. The SWFSC Fisheries Resources and Protected Resources Divisions, along with a contracted commercial swordfish fisherman, worked together to conduct the experimental longlining. The goal was to deploy satellite and archival tags for both long- and short-term deployments in an area where leatherback turtles have been observed. In this way, swordfish behavior could be linked to available oceanography including in situ data collected during the cruise, satellite imagery, and model results (for a brief cruise report see Appendix C).

2. Examine the oceanography and other environmental factors associated with all catch records for all swordfish fishing activities currently and formerly conducted off Central California.

In addition to vertical habitat use, data on horizontal habitat use, for example, determining how swordfish use frontal features and what signals their arrival in near-shore waters, is also required for optimal model development. One option proposed to examine horizontal habitat use is to conduct a detailed examination of logbook and observer records for the DGN fishery when it operated north of Point Conception and to link these catch records to regional environmental conditions. In addition, the catch data from any efforts to deploy electronic tags could be examined in a similar way. Comparison of catch across years with differing environmental conditions would provide insight into factors influencing the arrival of swordfish into the region.

3. Conduct diet studies of swordfish caught north of Point Conception.

Studies of foraging ecology would be conducted coincident with any effort to deploy electronic tags. In addition, if the proposed EFP is approved by NMFS, stomachs would be collected from swordfish caught north of Point Conception. Stomach contents would be examined to look at the relative contribution by weight, number, and frequency of the different prey types. The Large Pelagics Biology Lab at the SWFSC has an ongoing project to examine swordfish foraging ecology in the Southern California Bight and could easily expand this study.

C. Leatherback Sea Turtles

i. Background

Populations of critically endangered Pacific leatherback turtles (IUCN 2004) have declined precipitously during the past 25 years. A portion of the western Pacific population that breeds in Papua Barat (Indonesia) migrates to foraging grounds off the West Coast of North America where incidental takes have occurred in the swordfish DGN fishery (Dutton et al. 2007; Benson et al. 2007a; Carretta et al. 2004; Julian and Beeson 1998). Previous ecosystem studies of leatherback turtle foraging habitat off California have been confined to shelf waters (<90 m depth) within 30 miles of the coast (Benson et al. 2007b); however, telemetry studies of leatherbacks have suggested they also associate with dynamic oceanographic features (e.g. fronts) within the traditional swordfish fishing area (Benson, unpublished data). Therefore, data are needed to evaluate use of offshore waters where frontal features may aggregate jellyfish prey and provide foraging habitat for leatherbacks. Future studies involving oceanography and prey sampling will be needed to examine and characterize the abiotic and biotic conditions that create and define leatherback foraging habitat within the offshore waters of Central California.

ii. Data Gaps:

1. Characterization of leatherback use of near-shore and offshore habitat, including vertical habitat use and how foraging is influenced by the environment.
2. Determination of the timing of the turtles' departure from coastal foraging areas and subsequent transit through historic swordfish fishing grounds.
3. Factors affecting the abundance and distribution of jellyfish, the main prey of leatherbacks.
4. Factors affecting gear interaction.

iii. Strategy:

1. Characterize leatherback habitat use via telemetry, aerial surveys, and shipboard surveys.

In near-shore waters, leatherback habitat use has been documented since 2000 through fine scale aerial surveys and limited boat-based oceanographic sampling. Beginning in 2005, a few deployments of suction cup VHF radio tags with time depth recorders (TDRs) provided the first information on near-shore diving and foraging behavior (Benson et al. 2007b). These studies will continue during 2008 and beyond, funding permitting. Deployments of satellite and VHF telemetry devices on nesting and foraging leatherbacks between 2000 and 2007 have yielded information on movements to, and use of, near-shore foraging areas off the U.S. West Coast. Analyses of these data are presently underway to identify high-use areas, document daytime vs. nighttime movement rates, and describe diving patterns.

Studies of habitat use in offshore waters will require surveys that utilize remotely sensed and in situ oceanographic data to identify dynamic frontal features – physical mechanisms (i.e., surface currents) that might aggregate jellyfish and leatherback turtles. The LUTH survey will provide the first opportunity to collect these data. The results of this cruise will be used to characterize the ecosystem in the central California swordfish fishing grounds, and its use by leatherback turtles, by combining in situ multidisciplinary oceanographic sampling with aerial surveys for leatherbacks and satellite telemetry data. Results will be used to develop methods to identify leatherback foraging areas in offshore waters via remotely sensed surface features, thereby allowing fishers to avoid areas of potential interaction with leatherbacks.

2. Determine timing of leatherback departure from coastal foraging areas using VHF telemetry and aerial surveys.

The majority of existing satellite telemetry data on leatherbacks (see above) is not suitable for estimating departure time from the foraging grounds, because the process of in-water capture appears to cause most leatherbacks to leave the foraging area prematurely (Dutton unpublished data). Suction-cup VHF telemetry devices, monitored by aircraft (range 5-15 km) offer an alternative means of monitoring the presence of leatherbacks at coastal foraging areas and estimating the departure time of undisturbed turtles. Preliminary studies using suction cup VHF tags (without adhesives) have achieved maximum deployment duration of five days. The use of adhesives on suction cup telemetry devices offers promise to achieve longer attachment durations (weeks to months), but requires further development. We have also been developing techniques to quantify jellyfish biomass at foraging locations along the California coast, and plan to test a new suction cup attached video camera system to record leatherback foraging behavior and determine if the rate of consumption or size of prey decreases during the fall as water temperatures decrease, prompting leatherbacks to leave the foraging ground. Test deployments of this video system are planned for fall 2008.

3. Develop methods to quantify the abundance and distribution of jellyfish.

One large data-gap identified was the lack of information on the abundance and distribution of jellyfish. Unfortunately large-scale studies of jellyfish are lacking and would be difficult to fund. A number of potential options were identified, including initiating discussions with observer programs and with scientists who conduct regular surveys (e.g. CalCOFI, marine mammal surveys). Documentation of information on sightings of jellyfish could be requested as part of their regular course of operations. This would require the development and distribution of a scientific key for basic species identification as well as a list of additional information that would be useful to record. It may also be possible to review existing observer records in search of information on jellyfish that may have been previously documented.

4. Examine DGN fishery records to identify factors that influence probability of leatherback/fishing gear interaction.

There is a relatively large database covering the catch of the DGN fleet that previously operated north of Point Conception. This dataset includes the 23 observed sets in which leatherback sea turtles were taken prior to the closure of this area. Suggestions were made to more closely examine the sets in which these animals were taken, including the experience of the captain, the environmental characteristics at the location, the time of day leatherbacks were caught and the other species caught in association with the turtle. Recent data indicate that leatherback distribution and movements vary in response to ocean conditions.

II. Economics

The Economics Working Group discussed possible research projects aimed at conserving sea turtles and maintaining the economic viability of commercial fisheries that interact with sea turtle populations. A brief summary of potential topics is offered below:

A. Measuring the Economic Impacts of Regulatory Closures on Industry

i. Background

Time/area closures are frequently used to manage fisheries and protected species bycatch. If a closure has the effect of eliminating fishing effort in areas where productivity is higher than in areas still open to fishing, a drop in productivity and producer profits may result, as fishermen are constrained to fishing in less productive areas. In addition to economic implications, closures can also result in increases in bycatch in international waters. Such so-called transfer effects can be due to both economic and biological factors: 1) a reduction in domestic supply results in an increase in the demand for imports; and 2) a reduction in domestic effort reduces partial mortality on the target stock, increasing its availability to the foreign sector. Both factors may serve to stimulate an increase in swordfish imports in response to a unilateral reduction in domestic fishing effort, with an unforeseeable increase in the net level of sea turtle bycatch.

ii. Data Gaps

1. Statistical evidence on whether regulations that limit west coast-based swordfish fishing effort result in a transfer of swordfish fishing effort into other fisheries.
2. Data which could be used to measure the magnitude of any transfer of effort due to regulatory limits on west coast swordfish effort.
3. Data on sea turtle interaction rates in fisheries that either supply the U.S. import market or that might experience an increase in effort in response to regulatory limits on west coast-based effort.

iii. Strategy

1. Review existing data sources to document what could be used to quantify transfer effects and sea turtle interaction rates in other fisheries.
2. Identify data gaps which would need to be filled in order to estimate effort transfer effects and possible resulting increases in sea turtle interactions in other fisheries besides west coast-based swordfish fisheries.

3. Devise and implement a data collection strategy to fill these data gaps.

Proposed research would: 1) gauge the impact of the DGN leatherback conservation area closure on the productivity and economic viability of the fishery; and 2) evaluate the economic and conservation impacts of any transfer of effort which resulted due to a unilateral reduction in domestic DGN swordfish production. Methods similar to those employed in Rausser et al. (2008) would be applied in conjunction with a productivity analysis that considers conservation impacts to gauge the net impact of the 2001 leatherback conservation closure on the productivity of the DGN fishery.

B. Conservation Investments

i. Background

Recent discussions have considered the contribution of conservation investments and mitigation to biodiversity conservation, particularly in developing countries (Bean 1993; Roberts 1999; Heal 2000; Wilcox and Donlin 2007; Dutton and Squires 2008.) Such an approach has been endorsed by the Convention on Biological Diversity (Slootweg et al. 2006), although controversy still surrounds the approach, despite its widespread application (Burgin 2008). Conservation investments may be promising for leatherback sea turtles (Janisse et al. *in press*).

It has been noted in numerous publications that the conservation and recovery of leatherbacks must include protection of nesting beaches, along with reducing incidental takes in fisheries. By improving the nesting habitat of leatherbacks and therefore increasing the number of hatchlings, the overall status of the population should improve. Gjertsen (*in press*) found that nesting beach protection was an appreciably more cost effective conservation strategy than at-sea protection through regulating the Hawaii SSLL and California DGN fleets.

One option for this type of conservation investment that could help improve the status of leatherback sea turtles involves a combination of NGO, consumer, and industry financing to protect turtle nesting beaches used by animals impacted by the fishery. These conservation investments should help improve the overall status of the species, consistent with section 7 of the ESA. Under the U.S. ESA, Federal agencies are encouraged to use their programs to help in the conservation of threatened and endangered species. The SLUTH team is exploring how conservation measures can be integrated into fishery actions in such a way to improve the status of species that may be affected by the fishery.

Another option that was explored was reducing the mortality of turtles returning to unprotected nesting beaches. Investments could be made to improve the oversight and monitoring at nesting beaches to safeguard the presence of adults, the deposition of eggs, and the emergence of hatchlings. Investments could also be made to alter gear and fishing practices around nesting beaches. Such conservation measures generally do not jeopardize the economic viability of fisheries, and as shown by Gjertsen (*in press*), are more cost effective, by an order of magnitude or more. Part and parcel to these investments would be to work with local communities to empower them to take ownership and champion the cause of leatherback protection and conservation. If actions to reduce mortalities are reasonably likely to be successful and are contemporaneous with the action, then the conservation benefit to the species is more clear and immediate.

A possible funding mechanism is the use of a double dividend tax approach to pay for environmental mitigation measures. Such measures may have to be voluntary, such as the current voluntary payments by FISH (Federation of Independent Seafood Harvesters) to ASUPMATOMA, a Mexican conservation group, to aid their Pacific leatherback turtle nesting site protection (Janisse et al., *in press*). A double dividend tax is documented to promote conservation objectives directly by taxing the fishery and indirectly through using the tax proceeds to finance conservation. An issue that would need to be addressed is the feasibility of basing a tax on estimated bycatch rates (Segerson *in press*). Given the international scope of sea turtle bycatch, any tax on the U.S. industry would ideally be matched by a commensurate tax on foreign producers in order to avoid a potential transfer of effort and turtle bycatch to the foreign sector. These efforts could be undertaken in a cooperative fashion with NGOs, industry, or governments working internationally.

ii. Data Gaps

1. Information on the existence and success of environmental conservation investments used in other fisheries to improve the status of sea turtles and/or reduce or eliminate protected species bycatch.
2. A review of environmental conservation investments used in other contexts.
3. Evidence on whether any of the methods identified could potentially be applied to known sea turtle conservation problems.

iii. Strategy

1. Conduct literature review to explore 1) and 2) above.
2. Study the use of conservation investments as a potential policy tool.

This research would identify and describe alternative industry-funded conservation investment strategies from the standpoints of feasibility and cost effectiveness. A potential outcome is to identify a means to simultaneously achieve sustainable U.S. fisheries and increased sea turtle conservation.

C. Integrating Economics into Sea Turtle Conservation

i. Background

A holistic conservation strategy that addresses all sources of anthropogenic mortality is the best hope for conserving Pacific leatherback sea turtle populations (Dutton and Squires 2008; Steering Committee, Bellagio 2004; 2008). One important question is the cost effectiveness of alternative sea turtle conservation strategies. For example, would a dollar spent on reducing sea turtle interactions in fisheries or destruction of nesting beaches achieve the greatest conservation benefit? Gjertsen (*in press*) has shown that nesting beach conservation is cheaper and likely to be more effective than bycatch reduction measures by themselves. However, at sea conservation measures are desirable to complement nesting beach conservation. There are several approaches to reducing potential adverse impacts of fisheries. Research comparable to that on the Hawaii longline fishery by Segerson (*in press*) and Ning et al. (*in press*), but focused on the DGN fishery for the most economically efficient method of at-sea conservation is necessary. Furthermore, the impact of alternative sea turtle conservation strategies on artisanal fishers and coastal fishing communities and conversely, the fishers' impacts on sea turtle mortality need to be further evaluated.

U.S. regulations including the ESA and the MSRA provide the opportunity to focus conservation efforts internationally. New measures in the MSRA include a certification program that identifies nations whose vessels engage in protected species bycatch. If nations receive a negative certification, imports can be prohibited. The advantages of the MSRA certification program could be compared to other trade measures. Other potential measures include the use of an import tariff for fisheries with a greater impact on leatherback turtle mortality. Similarly, Section 8 of the ESA stipulates assistance to foreign countries to help in the development and management of programs aimed at the conservation of ESA-listed species. Programs that provide direct payments for conservation have been considered in theory (Ferraro 2007) but have only been attempted on a very limited basis.

ii. Data Gaps

1. Relevant examples of applications of Section 8 of the ESA to provide assistance to foreign countries to help in the development and management of programs aimed at the conservation of ESA-listed species.
2. Examples of application of MSRA requirements to work internationally at reducing bycatch of protected living marine resources.
3. Evidence on whether similar measures might be effective for addressing sea turtle conservation concerns in west coast-based swordfish fisheries.

iii. Strategy

1. Review available information regarding the range of conservation measures employed in other U.S. fisheries facing similar sea turtle conservation problems as those faced by west coast-based swordfish fisheries.
2. Obtain information that could be used to evaluate the cost and feasibility of employing alternative conservation strategies to those already in use (i.e. turtle caps, time/area closures, and gear restrictions) in west coast-based swordfish fisheries, being aware that a U.S. fishery cannot operate if it is likely to jeopardize the continued existence of an ESA-listed species.

This research would start with an international-level review of activities that pose threats to leatherback sea turtle populations, including industrial and artisanal fisheries, harvest of turtles or their eggs, and loss and degradation of coastal habitat. For example, artisanal and small-scale coastal fisheries throughout Asia, Indonesia, Ecuador, Peru, and Chile are believed to be significant sources of leatherback mortality. Information about the global distribution of threats to protected turtle populations would be used to explore the feasibility for formal and informal international agreements, gear research, and other sea turtle conservation initiatives. Part of the assessment process would be to determine the comparative advantage and efficiency of sea turtle conservation measures to the various countries involved. Next the research would seek to identify the most cost-efficient sea turtle bycatch mitigation and conservation measures and to develop mechanisms for equitable sharing of the costs over domestic consumers, producers, processors, and foreign producers.

D. Is Harpoon a Viable Substitute for Longline or Drift Gillnet Gear?

i. Background

Some commentators have suggested that harpoon gear could serve as an economically viable substitute for SSLL and DGN gear. There are no records of bycatch in west coast-based harpoon fisheries, leading some individuals to view harpoon as a potentially clean and economically viable substitute to using SSLL or DGN to target swordfish in the EEZ. This notion ignores the limitations of harpoon gear, and the comparative advantages of the three known commercial swordfish gear types.

Generally speaking, harpoon gear is best suited to near-shore calm water. Harpoon gear requires that individual fish are spotted basking near the surface during the day. Success depends on fish behavior and on a state of relatively calm seas and clear conditions. Off the California coast, the harpoon fishery is limited to the Southern California Bight. Due to inherent limitations of harpoon gear and the high fossil fuel costs of searching for individual swordfish basking on the surface, many fishing industry participants believe it is not an economically viable substitute for longline or DGN gear.

ii. Data Gaps

1. Cost and earnings data that reflect the economic viability of using different gear and techniques for west coast-based swordfish fishing.
2. Data on sea turtle take rates and other bycatch rates for alternative fishing modes off the West Coast.

iii. Strategy

1. Consider the feasibility of conducting experiments inside the west coast EEZ with alternative swordfish fishing modes to collect relevant bycatch and cost and earnings data for harpoon, DGN, and longline fishing. These data would be used in conjunction with PacFIN fish ticket data to compare the fisheries from the standpoints of environmental impacts and economic viability.

III. Management/Policy Issues

Given the vocal opposition to DGN and/or SSLL fishing on the West Coast on the one hand, and the need for approval of important research and exploratory opportunities on the other, obtaining support from a range of parties prior to engaging in any future cooperative research plan will be imperative. These parties include NGOs, NOAA, the fishing industry, the legislature, and the public. The adversarial political climate resulting from litigation and ongoing opposition from various factions has made it difficult to even engage in a broad policy debate on U.S. west coast fisheries management, or to objectively review proposals and develop initiatives that attempt to reconcile fishing with conservation. To open lines of communication among the diverse stakeholders will require education and outreach both within and outside NOAA.

The SWR has initiated outreach and education efforts to address concerns about swordfish fisheries off the West Coast, including the goals and objectives of the proposed experimental fishing permit using innovative SSLL gear to target swordfish. The SWR and SWFSC have also been working to develop research projects that align with regional management needs. The current SLUTH workshop is an outcome of efforts to develop a coordinated research initiative and to bring industry representatives into the conversation.

As part of the education and outreach program for SLUTH, this report as well as additional supplementary information will be distributed and additional workshops with the various stakeholders will be conducted. When appropriate, information will be distributed via the FishWatch website[4]. Some elements of the education/outreach program viewed as critical by the SLUTH participants are detailed below.

A. Promote the Concept of Ecological Footprint of International Versus Domestic Fisheries

In the Pacific Ocean leatherback recovery will be best served by a healthy domestic fishery with low bycatch and mortality levels coupled with a holistic approach to conservation (Dutton and Squires 2008). The concept of a fishery's "ecological footprint" needs to be further developed and could become an integral component of any outreach campaign. The ecological footprint will include not only turtles taken in domestic or international fisheries, but all target and non-target species that are both marketable and discarded. In particular, it will be important to include sharks, given the global concern about population levels (Bonfil 1994; Myers et al. 2007). Questions that need to be addressed are detailed below. When progress requires additional information, data gaps and strategies are identified.

i. Which U.S. fishery (SSLL versus DGN) has the smallest ecological footprint (i.e. Cleanest Gear Concept)?

1. Background

Both DGN and SSLL are effective gears for targeting swordfish. Based primarily on a time series of DGN observer records, and without considering protected resource interactions, it has been suggested that the ecological footprint associated with finfish bycatch is higher for DGN gear than it is for SSLL gear, even prior to the gear modifications mandated in 2004. Unfortunately, a direct ecological or economic comparison of the two gear types is not possible because of the geographic separation between the two fisheries. The DGN fishery has operated in the U.S. EEZ from the U.S./Mexico border to the Oregon/Washington border but is now constrained primarily to the Southern California Bight due to the PLCA. The swordfish longline fishery has operated primarily outside the U.S. EEZ on the high seas. Nonetheless, observer data are informative in demonstrating differences in the numbers of discarded bycatch (Appendix D).

While comparisons are limited, one can gain insight into potential economic and ecological differences by comparing the catch ratio of target species to non-target species caught[5] using observer data from these two fisheries. One approach is to calculate the numbers of swordfish

[4] www.nmfs.noaa.gov/fishwatch/

[5] With the addition of price data for marketable species catch, one can use such information to relate the financial value of target species (swordfish) catch per 100 incidental catch of a given non-target species.

caught per 100 non-target species caught examining species that are both marketable and discarded bycatch (Appendix D).

From an economic standpoint, NMFS is interested in the question of how many marketable species are caught for a given level of discarded bycatch. One can address this question by considering the right-most columns in the table (Appendix D) showing the numbers of swordfish caught per 100 non-target species, specifically those that are not marketable.

A similar approach can be used to compare the ecological footprint of the two fisheries considering all species. A quick comparison of the two gear types suggests that the number of swordfish caught per 100 non-target finfish species (both marketable and discarded bycatch) is typically higher for longline gear (Appendix D), indicating a lower rate of bycatch. Overall, eight times as many non-target finfish were taken with DGN gear in the EEZ for every swordfish caught in comparison to SSLL gear outside the EEZ. Comparisons between the two fisheries are, however, complicated by the geographic separation of the fisheries and shifts in species distributions. Also, the California Current, where the DGN fishery primarily operates, is a highly productive boundary current system that may have a greater abundance of fish vulnerable to this gear type.

2. Data Gaps

a. Protected species and non-target finfish catch rates (including discarded and marketable species) using modified SSLL and DGN gear in historic swordfish fishing grounds in the U.S. EEZ.
b. The economic viability of SSLL and DGN gear under present market conditions, considering all losses and gains due to fishing activity costs including valuation based on the ecological footprint.

3. Strategy

a. Conduct gear comparison studies to examine composition of catch, both target and non-target species, with special attention to sharks.

An experiment employing SSLL and DGN gear in the PLCA during the fall would help identify differences in the swordfish catch and incidental-take rates for the two gear types. The SSLL used would need to conform to the configuration recently proven in the Hawaii SSLL fishery to reduce sea turtle interactions (i.e. circle hooks and mackerel-type bait). Conducting an experiment during the same season and area should implicitly control for influences that vary across time and location, narrowing the comparison to differences in catch rates and economic viability that are attributable to the distinct gears. Given the long time series data available for DGN observer trips, a scaled-back version of the experiment using only SSLL could be considered. In order to conduct a robust experiment, a power analysis will be needed to determine the number of sets required to obtain a statistically valid comparison. An important component of this experiment would be an evaluation of the economic viability of the two gear types, which requires a comparison of their respective idiosyncratic costs such as bait, net repair, crew, light sticks, pingers, onboard processing time, fuel, etc.

In addition to comparing the ecological footprint of the two gear types, longline operations would provide the opportunity to test gear and bait modifications to minimize bycatch of non-target species, focusing mainly on sharks, but also on rarely caught species such as turtles. The shark species with the highest catch rate in both the DGN and offshore SSLL fishery is the blue shark, which has no market value in the U.S. There are a number of experimental methods under development that show promise in reducing shark bycatch including chemical and electropositive/electromagnetic deterrents (Gilman et al. 2007). Given the high catch rates of sharks, statistically significant results could be obtained with relatively few sets, the number of which would be determined using power analysis. For limiting turtle bycatch, gear modifications that have been proposed include altering the wavelengths emitted by light sticks or shading them so they cannot be seen from above (Wang et al. 2007). Tests on new light sticks could be initiated in the experimental fishery although given the low catch rates of sea turtles, additional studies, possibly in the laboratory or in other areas, may be necessary to make conclusions. In addition, the impacts of different methods on the catch rates of target species could also be calculated. Any experiment would need to be conducted in a way that ensures it does not jeopardize any ESA-listed species.

ii. Where is imported swordfish coming from by season? What management measures, regulations and levels of enforcement exist for those fisheries?

1. Background

Developing greater public awareness of the ecological costs of importing swordfish is critical to efforts to encourage a sustainable U.S. fishery. To estimate this ecological cost requires detailed information on the fisheries from which swordfish are being imported, an assessment of their regulations and fishing methods including hook and bait type, and an estimation of the leatherback bycatch in these fisheries.

2. Data Gaps

a. Fisheries dependent and independent information from foreign swordfish fleets and associated marketing and export sectors.
b. An assessment of management measures and fishing practices in countries from which swordfish are imported into the U.S.

3. Strategy

a. Survey importers and exporters supplying the U.S. market throughout the year to assess the relative contribution of different fleets.
b. Survey international fisheries to obtain an estimate of the ecological footprint.

The approach will be to identify countries providing the majority of U.S. imports annually and examine the regulations, enforcement, and fishing practices. It will be necessary to examine temporal and spatial patterns in fishing activity with the probability of overlap with turtle habitat, factoring in migratory patterns and time spent on foraging grounds. This may include increased observer coverage/data, expanded port sampling programs, and cooperative information exchange programs with regional fishery management organizations.

B. Develop Internal NOAA Support (Regions, Science Centers, and Headquarters).

The campaign to build internal support will require reaching out to NOAA Regional and National line offices and NOAA Fisheries leadership in Silver Spring. In addition, working with NOAA headquarters to tie regional initiatives to international efforts to implement new requirements under MSRA will be important.

C. Bring Conservation NGOs Onboard.

One key partnership that needs further development is between the existing SLUTH team and the NGO community. The SLUTH team has contacted several NGOs that have shown a genuine interest in working cooperatively with managers and fishermen to support the cleanest swordfish fisheries possible for the West Coast, recognizing the importance to turtle conservation of fostering U.S. domestic fisheries. Two in particular, the World Wildlife Fund (WWF) and The Nature Conservancy (TNC), have actively partnered with SWFSC scientists to address Pacific sea turtle conservation within a multidisciplinary framework that goes beyond just bycatch reduction in high seas fisheries (Steering Committee, Bellagio Workshop, 2004; 2008). In addition, WWF has sponsored the International Smart Gear Competition that brings together fishing industries, research institutes, universities, and government to inspire and reward practical, innovative fishing gear designs that reduce bycatch.

CONCLUSIONS:

The SLUTH workshop brought together a multilateral consortium of diverse stakeholders interested in maintaining healthy leatherback sea turtle populations while supporting viable U.S. swordfish fisheries. Stakeholders include the fishing industry, scientists, fisheries managers, and policy makers with the goal of including NGO's in future efforts. A prime concern of workshop participants was the possibility that the management measures, while detrimentally impacting west coast swordfish fisheries, may have resulted in an overall increase in turtle take due to a transfer effect to foreign fleets. The goal of the workshop was to explore how to couple adaptive fisheries management schemes with a holistic approach to leatherback sea turtle conservation, to the benefit of both leatherback populations and the U.S. fishing industry. Having an active, well managed and regulated U.S. fishery provides leverage to promote Pacific-wide sea turtle conservation. Such a fishery also provides an incentive to develop innovative bycatch reduction gear and alternative methodologies that can be exported to other countries whose fishing fleets interact with leatherback turtles.

Throughout the workshop, the group identified scientific, economic, and policy data gaps and strategies needed to develop a more adaptive management scheme for domestic swordfish fisheries while achieving low bycatch of leatherback sea turtles and advancing Pacific-wide conservation efforts. Central to achieving the above goal is gathering additional information on the habitats of both swordfish and leatherbacks, respectively, to allow for the possibility of predictive modeling, as well as identifying methods to maximize the selectivity of fishing gear and minimize the ecological footprint of U.S. fleets while maintaining economic viability and U.S. supply. Any mechanisms or management schemes identified and proven successful can then be exported internationally.

When possible, the economic and policy implications of the current management regime need to be quantified. This approach will help identify the most efficient options for domestic and international fisheries management and turtle conservation. The SLUTH workshop was the first step in moving forward in these efforts and will be a foundation for seeking funding and support for a multi-year and multi-faceted effort. This effort incorporates ecosystem considerations into the management of U.S. fisheries and protected species.

ACKNOWLEDGEMENTS:

The collaborative and productive nature of the workshop is a testament to the efforts put forth by all the workshop participants. We thank them for their valuable time and input. The content of the workshop report represents the combined contributions of a large group of people who all deserve recognition and thanks including Suzanne Kohin, Tomo Eguchi, Elizabeth Petras, Heidi Hermsmeyer, and Yonat Swimmer. We also thank Steve Foltz, Scott Aalbers, Peter Flournoy, Pete Dupuy, Jeremiah O'Brien, Kathy Fosmark, Bill Sutton, Jim Lecky, Roger Hewitt, Anne Allen, Russ Vetter, Lisa Ballance, Jeffrey Seminoff, Chris Yates, Heidi Taylor, Mark Helvey, Siri Hakala, Adam Bailey and Alvin Katekaru for their valuable comments and editorial assistance.

<u>REFERENCES:</u>

Arnold, G. and H. Dewar. 2001. Electronic tags in marine fisheries research: A 30-year perspective. In*:* Sibert, J. R. and J. L. Nielsen (eds.). Electronic tagging and tracking in marine fisheries. Dordrecht, The Netherlands: Kluwer Academic Publishers. p. 7-64.

Bean, M. 1993. Incentive-based approaches to conserving red-cockaded woodpeckers in the Sandhills of North Carolina. *In* W.E. Hudson (ed.) Building Economic Incentives into the Endangered Species Act. Washington, D.C.: Defenders of Wildlife.

Benson, S. R., P. H. Dutton, C. Hitipeuw, B. Samber, J. Bakarbessy, and D. Parker. 2007a. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1):150–154.

Benson, S. R., K. A. Forney, J. T. Harvey, J. V. Carretta, and P. H. Dutton. 2007b. Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990-2003. Fishery Bulletin 105(3):337-347.

Bonfil, R. 1994. World bycatches of sharks in high-seas fisheries: Appraising the waste of a resource. In*:* Pitcher, T. J. and R. Chuenpagdee (eds.). Bycatches in fisheries and their impact on the ecosystem. Fisheries Centre Research Reports 2(1):41-44.

Burgin, S. 2008. Biobanking: an environmental scientist's view of the role of biodiversity banking offsets in conservation. Biodiversity and Conservation 126:186-194.

Carretta, J. V., T. Price, D. Petersen, and R. Read. 2004. Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996−2002. Marine Fisheries Review 66(2):21−30.

Coan, A. L., M. Vojkovich, and D. Prescott. 1998. The California harpoon fishery for swordfish, *Xiphias gladius*. In: I. Barrett, O. Sosa-Nishizaki, and N. Bartoo (eds.). Biology and fisheries of swordfish, *Xiphias gladius*. Papers from the International Symposium on Pacific Swordfish, Ensenada, Mexico, Dec. 11-14, 1994. U. S. Dept. Commer., NOAA Technical Report NMFS 142, 276 p.

Davenport, D., J. R. Johnson, and J. Timbrook. 1993. The Chumash and the swordfish. Antiquity 67:257-72.

Dewar, H., E. Prince, M. Musyl, R. Brill, C. Sepulveda, L. Jiangang, D. Foley, J. Seraphy, M. Domeier, D. Snodgrass, N. Nasby-Lucas, B. Block, M. Laurs, and L. McNaughton. *In prep.* The movements and behaviors of Pacific and Atlantic swordfish determined using pop-up satellite archival tags. Marine Ecology Progress Series.

Dutton, P. H. and D. Squires. 2008. Reconciling biodiversity with fishing: A holistic strategy for Pacific sea turtle recovery. Ocean Development & International Law 39:200-222.

Dutton, P. H., C. Hitipeuw, M. Zein, S. Benson, G. Petro, J. Pita, V. Rei, L. Ambio, and J. Bakarbessy. 2007. Status and genetic structure of nesting populations of leatherback turtles (*Dermochelys coriacea*) in the Western Pacific. Chelonian Conservation Biology 6(1):47-53.

Ferraro, P. J. 2007. A Global Survey of Sea Turtle Payment Incentive Programs. Project Report. Commissioned by Southwest Fisheries Science Center, National Marine Fisheries Service.

Gilman, E. S., D. Kobayashi, T. Swenarton, N. Brothers, P. Dalzell, I. Kinan-Kelly. 2007. Reducing sea turtle interactions in the Hawaii-based longline swordfish fishery. Biological Conservation 139(1-2):19-28.

Gilman, E., S. Clarke, N. Brothers, J. Alfaro-Shigueto, J. Mandelman, J. Mangel, S. Petersen, S. Piovano, N. Thomson, P. Dalzell, M. Donoso, M. Goren, and T. Werner. 2008. Shark interactions in pelagic longline fisheries. Marine Policy 32(1):1-18.

Gjertsen, H. *In press.* Can we improve our conservation bang for the buck? Cost-effectiveness of alternative leatherback turtle conservation strategies. In: Dutton, P. H., D. Squires, and M. Ahmed (eds.). Conservation of Pacific Sea Turtles. University of Hawaii.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981–82 through 1990–91. California Department of Fish and Game Fish Bulletin, vol. 175.

Harrington, J. M., R. A. Myers, and A. A. Rosenberg. 2005. Wasted fishery resources: Discarded by-catch in the U.S.A. Fish and Fisheries 6:350-361.

Heal, G. 2000. Nature and the Marketplace: Capturing the Value of the Ecosystem. Washington, D.C.: Island Press.

Helvey, M. and C. C. Fahy. *In review*. U. S. Fisheries Management: A Progressive Model for Sea Turtle Conservation. In: Seminoff, J. A. and R. Brusca (eds.). Sea Turtles of the Eastern Pacific Ocean: Natural History, Conservation Challenges and Signs of Success. University of Arizona Press.

Hitipeuw, C., P. H. Dutton, S. Benson, J. Thebu, and J. Bakarbessi. 2007. Population status and inter-nesting movement of leatherback turtles, *Dermochelys coriacea*, nesting on the northwest coast of Papua, Indonesia. Chelonian Conservation and Biology 6(1):28-36.

Holts, D. B. 1988. Review of U.S. West Coast commercial shark fisheries. Marine Fisheries Review 50(1):1-8.

Howell, E. A., D. R. Kobayashi, D. M. Parker, G. H. Balazs, and J. J. Polovina. 2008. TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles *Caretta caretta* in the Hawaii-based pelagic longline fishery. Endangered Species Research Fishery Bycatch Issue (available online at http://www.int-res.com/journals/esr/esr-home/).

IUCN (World Conservation Union). 2004. Species Survival Commission. Red List Database 2008. Website: http://www.iucnredlist.org/.

Janisse, C., D. Squires, J. Seminoff, and P. Dutton. *In press.* Conservation investments and mitigation: The California drift gillnet fishery and Pacific sea turtles. In: Grafton, Q., R. Hilborn, D. Squires, M. Tait, and M. Williams (eds.). Handbook of Marine Conservation and Management. Oxford: Oxford University Press.

Julian, F. and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fishery Bulletin 96(2):271-284.

Kato, S. 1969. Longlining for swordfish in the Eastern Pacific. Commercial Fisheries Review 31(4):30-32.

McShane, M., K. Broadhurst, and A. Williams. 2007. Keeping watch on the unwatchable: Technological solutions for the problems generated by ecosystem-based management. Fish and Fisheries 8:153-161.

Myers, R. A., J. K. Baum, T. D. Shepherd, S. P. Powers, and C. H. Peterson. 2007. Cascading effects of the loss of apex predatory sharks from a coastal ocean. Science 315:1846-1850.

National Marine Fisheries Service (NMFS). 2001. Endangered and Threatened Wildlife; Sea Turtle Conservation Requirements; Taking of Threatened or Endangered Species Incidental to Commercial Fishing Operations. Federal Register 66(165):44549-44552.

National Marine Fisheries Service (NMFS). 2001. Final Environmental Impact Statement for Fishery Management Plan, Pelagic Fisheries of the Western Pacific Region. March 30, 2001.

NMFS. 2004. Management Measures to Implement New Technologies for the Western Pacific Pelagic Longline Fisheries: A regulatory Amendment to the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region. March 5, 2004.

Ning, F. T., C. Zhang, and R. Fujita. *In press.* Quantitative evaluation of the performance of a permit auction system in reducing bycatch of sea turtles in the Hawaii Swordfish longline fishery. Marine Policy.

Pacific Fishery Management Council (PFMC). 2007. Status of the U.S. West Coast Fisheries for Highly Migratory Species through 2006, Stock Assessment and Fishery Evaluation. Portland, OR: PFMC. September 2007.

Rausser, G. C., M. Kovach, S. F. Hamilton, and R. Stifter. 2008. Unintended consequences: The spillover effects of common property regulations. Marine Policy 33(1):24-39. doi:10.1016/j.marpol.2008.03.020.

Roberts, B. 1999. Endangered species mitigation banking: promoting recovery through habitat conservation planning under the Endangered Species Act. Science of the Total Environment. October 28, pp. 2411-2419.

Sakagawa, G. T. 1989. Trends in fisheries for swordfish in the Pacific Ocean. In: Stroud, R. H. (ed.). Planning the Future of Billfishes: Research and Management in the 90s and Beyond. Proceedings of the Second International Billfish Symposium, Kailua–Kona, Hawaii, August 1–5 1988. Savannah, Georgia: National Coalition for Marine Conservation, Inc. p. 61-79.

Sarmiento, C. 2006. Transfer function estimation of trade leakages generated by court rulings in the Hawaii longline fishery. Applied Economics 38:183-190.

Segerson, K. *In press.* Polices to reduce stochastic sea turtle bycatch: An economic efficiency analysis. In: Dutton, P. H., D. Squires, and M. Ahmed (eds.). Conservation of Pacific Sea Turtles. Honolulu: University of Hawaii Press.

Slootweg, R., A. Kolhoff, R. Verheem, and R. Höft. 2006. Biodiversity in EIA and SEA. Background document to CBD decision VII/28: voluntary guidelines to biodiversity-inclusive impact assessment. Netherlands: Commission for Environmental Assessment.

Steering Committee, Bellagio Conference on Sea Turtles. 2004. What can be done to restore Pacific turtle populations? The Bellagio Blueprint for Action on Pacific Sea Turtles. Penang, Malaysia: The WorldFish Center. 24 p.

Steering Committee, Bellagio Sea Turtle Conservation Initiative. 2008. Strategic Planning for Long-term Financing of Pacific Leatherback Conservation and Recovery: Proceedings of the Bellagio Sea Turtle Conservation Initiative; July 2007; Terengganu, Malaysia. Penang, Malaysia: The WorldFish Center. 79 p.

U.S. Department of Commerce Commercial Fishery Landings. 2008. http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

U.S. Department of Commerce U.S Foreign Trade. 2008. http://www.st.nmfs.noaa.gov/st1/trade/index.html

Vojkovich, M. and K. Barsky. 1998. The California-based longline fishery for swordfish, *Xiphias gladius*, beyond the U.S. Exclusive Economic Zone. U.S. National Marine Fisheries Service, NOAA Technical Report. NMFS 142:147-152.

Wang, J. H., L. C. Boles, B. Higgins, and K. J. Lohmann. 2007. Behavioral responses of sea turtles to lightsticks used in longline fisheries. Animal Conservation 10:176-182.

Watson, J. W., S. P. Epperly, A. K. Shah, and D. G. Foster. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Canadian Journal of Fisheries and Aquatic Sciences 62:965-981.

Watson, J. W. and D. W. Kerstetter. 2006. Pelagic longline fishing gear: A brief history and discussion of research efforts to improve selectivity and sustainability. Marine Technology Society Journal 40(3):5-10.

Wilcox, C. and J. Donlan. 2007. Resolving economic inefficiencies: compensatory mitigation as a solution to fisheries bycatch-biodiversity conservation conflicts. Frontiers in Ecology and the Environment 5(6): 325-331.

APPENDIX A:

List of workshop participants

SLUTH Attendance List

Name	Affiliation	E-mail address
Andrew White	Fisherman	drewwhitek@yahoo.com
Arthur Lortow	F/V *Beva*	Dee-dee-2@juno.com
Bill Sutton	Fisherman/HMSAS	SEAFRESHTO@aol.com
Charles Villafana	NMFS/SWR	Charles.Villafana@noaa.gov
Christina Fahy	NMFS/SWR	Christina.Fahy@noaa.gov
Chugey Sepulveda	PIER Researcher	chugey@pier.org
Craig Heberer	NMFS/SWR	Craig.Heberer@noaa.gov
Dale Squires	NMFS/SWFSC	Dale.Squires@noaa.gov
Dale Sweetnam	CDFG, La Jolla	Dale.Sweetnam@noaa.gov
Darin Maurer	Spotter pilot	DCMFLYN@hotmail.com
Elizabeth Petras	NMFS/SWR PRD	Elizabeth.Petras@noaa.gov
George Shillinger	Hopkins Marine Station/Stanford	georges@stanford.edu
Heidi Dewar	NMFS/SWFSC	Heidi.Dewar@noaa.gov
Heidi Hermsmeyer	NMFS-SFD/SWR	Heidi.Hermsmeyer@noaa.gov
Jeff Seminoff	NMFS/SWFSC	Jeffrey.Seminoff@noaa.gov
Jenny Purcell	Western Washington University	purcelj3@wwu.edu
Jeremiah O'Brien	MBCFO/WFOA	T.JOBrien@sbcglobal.net
Jeremy Rusin	NMFS/SWFSC	Jeremy.Rusin@noaa.gov
John LaGrange	Fisherman	John.LaGrange@gmail.com
Kathy Fosmark	PFMC member	swordstuna@aol.com
Kelly Fukushima	Fisherman	nursejogene@cox.net
Leeanne Laughlin	CDFG, Los Alamitos	llaughlin@dfg.ca.gov
Lyle Enriquez	NMFS/SWR	Lyle.Enriquez@noaa.gov
Mark Helvey	NMFS/SWR	Mark.Helvey@noaa.gov
Oscar Sosa-Nishizaki	CICESE	ososa@CICESE.MX
Pete Dupuy	HMSAP	LaPazKD@aol.com
Peter Dutton	NMFS/SWC	Peter.Dutton@noaa.gov
Peter Flournoy	International Law offices	phf@pacbell.net
Robin LeRoux	NMFS/SWFSC	Robin.LeRoux@noaa.gov
Scott Aalbers	PIER Researcher	Scott@pier.org
Scott Benson	NMFS/SWFSC	Scott.Benson@noaa.gov
Siri Hakala	NMFS/SWFSC	Siri.Hakala@noaa.gov
Stephen Stohs	NMFS/SWFSC/HMSMT	stephen.stohs@noaa.gov
Steve Foltz	Chesapeake Fish Co.	sfoltz@chesapeakefish.com
Steve Fosmark	HMSAS	FVS.EEADLER@aol.com
Steven Bograd	NMFS/SWFSC	Steven.Bograd@noaa.gov
Suzy Kohin	NMFS/SWFSC	Suzanne.Kohin@noaa.gov
Tara Scott	NMFS/SWFSC/VIMS	tlscott@vims.edu
Therese Conant	NMFS/PR HQ	Therese.Conant@noaa.gov
Tim Mulcahy	WFOA	FVCALOGERA@yahoo.com
Tomo Eguchi	NMFS/SWFSC	Tomo.Eguchi@noaa.gov
Trudi O'Brien	MBCFD	t.jobrien@sbcglobal.net
Yonat Swimmer	NMFS PIFSC	Yonat.Swimmer@noaa.gov

APPENDIX B:
SLUTH Workshop Agenda

May 28: 9:00 a.m. - 3:00 p.m.

Opening Remarks – Peter Dutton (SWFSC), Mark Helvey (SWR)

Introduction - Peter Flournoy, Facilitator
Housekeeping

- finalize agenda
- workshop schedule

Presentations

- Overview and Current Status of the Swordfish Fishery off the West Coast
    - Craig Heberer (SWR) – Summary of West Coast DGN, Harpoon, and Longline fisheries for swordfish
    - Oscar Sosa Nishizaki - Description of swordfish fisheries off Northern Baja, Mexico
    - Tina Fahy (SWR) – History of protected resources management related to West Coast swordfish fisheries, including recent leatherback Critical Habitat petition
    - Suzy Kohin (SWFSC) – Overview of swordfish stock status
    - Kathy Fosmark et al. – Fishers perspective (topic TBA)
- Oceanography of the California Current
    - Stephen Bograd (SWFSC)
- Jellyfish biology and distribution
    - Jennifer Purcell (Western Washington University) - Insights from jellyfish biology and distribution
- Gear innovations and fishing practices
    - Jeremiah O'Brien - Swordfish fishing practices and insights on habitat
    - Darin Mauer - Dynamics of spotting swordfish
- Past, Present, and Future Swordfish Research off the West Coast
    - Heidi Dewar - Swordfish vertical habitat use
    - Chugey Sepulveda - Fine scale habitat use

May 29: 8:30 a.m. – 5:00 p.m.

Presentations (cont.)

- Past, Present, and Future Leatherback Research off the West Coast
    - Scott Benson (SWFSC)
- Tools for Adaptive Management and Predictive Modeling
    - Steven Bograd (SWFSC) – PIFSC TurtleWatch Program
    - Tomo Eguchi (SWFSC) – Predictive modeling to minimize protective species fisheries interactions

Plenary Discussion

Open discussion. Review and elaboration of objectives and questions posed for the three working groups.

Working Groups (Divide into working groups to address topics)

- Reduction of encounter rates
  Step 1: Identify habitat overlap
  WG1: Habitat
    - Identify most pressing questions - is there spatial or temporal separation in habitat use of swordfish and leatherbacks?
    - Identify best methods, tools, experimental design, location, time, potential for data mining and the potential for dove-tailing with existing programs.
    - What is the role of fishermen/cooperative projects?

  Step 2: Developing strategies for adaptive management
  WG2: Predictive Modeling
    - Identify most pressing questions-what do fishers need? What do fisheries managers need?
    - What is needed for implementation?
      - Timing
      - Method
    - Role of fishermen/cooperative projects?

- Reduction of entrapment:
  WG3: Gear modification, both drift net and longline
    - What gear modifications exist that might be applicable?
    - What new innovative ideas are out there?
    - Logistics to develop and or test new or old methods
      - Is there a role for behavioral studies? What questions exist?
      - If so what studies could help understand and mitigate entanglement?
    - How do we move forward?
      - Role of fishermen/cooperative projects?

- Economics:
  Based on comments during the meeting it was clear that some discussion of economic options and considerations would be useful so this was added as a working group.

Reconvene Plenary Discussion - outcomes of Working Groups

Next Steps

- Research and Data Needs
- Outcome of workshop – development of cooperative research proposals
- Drafting workshop proceedings

Concluding Remarks

<u>APPENDIX C:</u>
Brief report from LUTH cruise.

Telemetry studies have revealed that endangered Western Pacific leatherback turtles (*Dermochelys coriacea*) associate with dynamic offshore oceanographic features (e.g., fronts) within a former part of the range of the California drift gillnet fishery. This fishery targeted primarily swordfish and was subject to a time/area closure in 2001 because of leatherback bycatch. To better understand the overlap of leatherbacks and swordfish and to support the development of new mitigation approaches, a multidisciplinary survey was conducted during August-September 2008 in this region. The Leatherback Use of Temperate Habitat (LUTH) survey, a collaborative 'process-oriented' ecosystem investigation sponsored by NOAA - Southwest Fisheries Science Center, involved oceanographic and prey sampling aboard the NOAA Ship *David Starr Jordan*. Components of the research included studies of swordfish habitat, near real-time satellite oceanography, and aerial surveys of leatherback turtles and their jellyfish prey. In addition, electronic tagging data were collected from leatherback turtles tagged at California foraging grounds and at Indonesian nesting beaches during summer 2007. The objectives of LUTH were: 1) to conduct an ecosystem assessment in offshore waters of central California, including traditional swordfish fishing grounds; 2) to identify leatherback foraging areas via shipboard oceanographic and prey sampling, aerial surveys, and satellite telemetry; 3) to identify swordfish habitat and to fish for and satellite tag swordfish; and 4) to determine how areas used by leatherbacks may overlap with swordfish habitat.

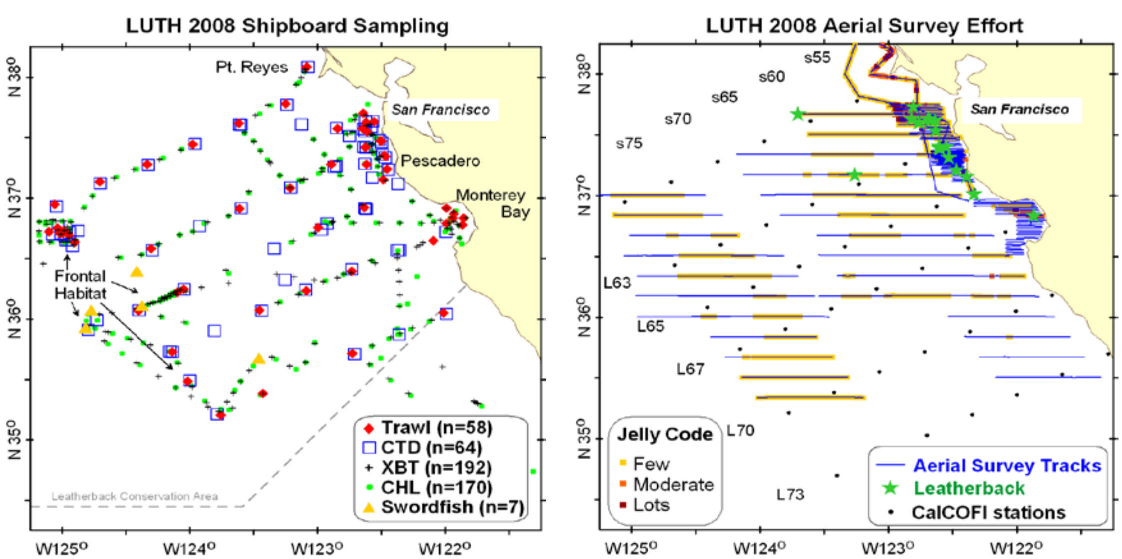

Figure C1. Cumulative plots of data collected during LUTH 2008 shipboard sampling and aerial survey efforts off the central coast of California. Swordfish include those either caught or observed.

The cruise was divided into two 14-day legs, and sampling was dynamic as features of interest were encountered. Daily satellite images from our land-based team helped guide the location of targeted sampling, and the aerial survey team documented turtles, jellyfish, marine mammals, and other species. During the first week, the team completed several CalCOFI (California Cooperative Oceanic Fisheries Investigations) stations and four night-time sets to catch swordfish for telemetry studies (Fig. C1). Four swordfish were caught and two were biologically sampled. During the second week, a detailed assessment of prey, oceanographic conditions, and the foraging behavior of three leatherbacks was completed in an important near-shore foraging area off San Francisco, as a comparison to offshore habitats. Weeks three and four yielded opportunities to conduct extensive sampling of an offshore frontal region and to complete a detailed sampling grid within the target study area (Fig. C1).

Preliminary results of the cruise indicate that the offshore frontal regions contain aggregations of large jellyfish that could provide foraging opportunities for migrating leatherbacks; however, offshore jellyfish aggregations were significantly less than those found in neritic waters. Jellyfish and jelly predators such as ocean sunfish (*Mola mola*) were consistently found on the cold-water side of these fronts, while the swordfish were seen and captured on the warm-water side. Several novel sampling techniques, including optical plankton analysis (AC-S) and a multibeam acoustic prey assessment were tested during this cruise and the results appear promising. Most significantly, the multidisciplinary approach that combined diverse sampling techniques in an adaptive sampling framework yielded many new insights into ecosystem processes and how species such as leatherbacks utilize the dynamic marine environment. The data will be analyzed during the coming year and results will provide a new foundation for developing conservation and management strategies to protect and recover leatherback turtles.

APPENDIX D:
Comparison of catch of the major finfish species observed in the California-based drift gillnet and shallow set longline fisheries.

Catch of the major finfish species for all observed CA-based shallow set longline sets, October 2001 through February 2004. N = 469.

Species	Total Obsvr Catch	Catch per 100 SWO	SWO Catch per 100 Finfish
Blue shark	5,575	74.2	135
Albacore tuna	460	6.1	1,633
Shortfin mako shark	249	3.3	3,017
Bigeye tuna	223	3.0	3,369
Pelagic stingray	125	1.7	6,010
Dorado	65	0.9	11,557
Common mola	51	0.7	14,729
Opah	36	0.5	20,867
Unidentified mako shark	33	0.4	22,764
Yellowfin tuna	18	0.2	41,733
Striped marlin	12	0.2	62,600
Billfish, Unidentified	12	0.2	62,600
Bluefin tuna	11	0.1	68,291
Skipjack tuna	10	0.1	75,120
Bigeye thresher shark	8	0.1	93,900
Blue marlin	4	0.1	187,800
Swordfish	7,512		

Catch of the major finfish species for all observed drift gillnet sets 1990 through January 2008. N= 7,891.

Species	Total Obsvr Catch	Catch per 100 SWO	SWO Catch per 100 Finfish
Common mola	49,691	298.5	33
Blue shark	21,692	130.3	77
Albacore tuna	16,564	99.5	100
Skipjack tuna	9,550	57.4	174
Shortfin mako shark	7,183	43.2	232
Pacific mackerel	6,210	37.3	268
Common thresher shark	5,945	35.7	280
Opah	4,548	27.3	366
Bluefin tuna	3,744	22.5	445
Bullet mackerel	3,020	18.1	551
Pacific bonito	941	5.7	1,769
Louvar	748	4.5	2,225
Bigeye thresher shark	607	3.6	2,742
Yellowfin tuna	512	3.1	3,251
Striped marlin	397	2.4	4,193
Pelagic thresher shark	77	0.5	21,618
Blue marlin	52	0.3	32,012
Bigeye tuna	20	0.1	83,230
Swordfish	16,646		