Proceedings of the International Technical Expert Workshop on Marine Turtle Bycatch in Longline Fisheries

Seattle, Washington, USA
11-13 February 2003

Editors:
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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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Silver Spring, Maryland

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Marine turtle populations have declined worldwide over the last century. All species have been listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since the Convention entered into force in 1975. The leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*) are listed as Critically Endangered under the Red List of the International Union for the Conservation of Nature (IUCN). The loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), and green turtle (*Chelonia mydas*) are listed as Endangered and the flatback (*Natator depressus*) is listed as Vulnerable on the IUCN Red List. Except for the flatback, which is indigenous to Australia, all species are listed under the U.S. Endangered Species Act of 1973.

Population declines have been documented in specific nesting assemblages of the loggerhead in the Atlantic and Pacific as well as the green turtle in the eastern Pacific. Of particular concern is the leatherback, which is seriously declining throughout the Pacific and has experienced an overall decline in the Atlantic. Once numbering in the tens of thousands, a 1996 study of the four major nesting beaches for the Pacific leatherback in Mexico, which sustained perhaps as much as half of all global nesting for this species, revealed that the population had collapsed. Annual surveys conducted since 1996 have revealed precipitously low population levels with only a few hundred females nesting annually along the entire Pacific coast of Mexico. The decline in these populations is due primarily to human-related causes, including incidental capture in commercial and artisanal fisheries and poaching of eggs and nesting females.

All species of marine turtles are caught in longline gear. Many nations support large fleets or are expanding their longline fisheries. With regard to incidental capture in commercial and artisanal fisheries, the high level of capture in pelagic longline fisheries is of particular concern. Incidental capture is documented for U.S. and international longline fisheries in the Atlantic as well as the Pacific. In the Pacific, approximately 28 nations have active longline operations. Dominant fisheries operating in the western Pacific and South China Sea include Japan and Taiwan. Fleets from the United States, Chile, Ecuador, and Costa Rica, plus Spanish fleets operating out of Peru, comprise a large portion of longline effort in the eastern Pacific. Dominant fisheries in the Atlantic include Brazil, Canada, Japan, Portugal, Spain, Taiwan, United States, Uruguay, and the Caribbean. For most of these fishing fleets, little or no data exist regarding the incidental bycatch of marine turtle populations. However, there are some observer and self-reporting programs that provide information on the magnitude of the problem. The number of turtles caught annually in the U.S. longline fleets operating in the Atlantic and Pacific is estimated in the thousands. Information from commercial logbooks, research vessel data, and questionnaires from longliners indicate that the Japanese tuna longliners operating in the western Pacific and South China Sea may incidentally capture a significant number of marine turtles annually. Records from an observer and questionnaire program in the Spanish longline fleet operating in the eastern Atlantic and Mediterranean also indicate a substantial number of takes per year. Globally, total incidental captures is severely impacting marine turtle populations.

To begin to address this conservation problem, and with the hope of developing global solutions, the United States convened this workshop consisting of technical experts on sea turtle biology and longline fishery operations from around the world. The objectives of the workshop included: (1) evaluating existing information on turtle bycatch in longline fisheries; (2) facilitating and standardizing collection of data from those longline fisheries that are likely to interact with marine turtles; (3) exchanging information on experimentation with longline gear relative to turtles and target species; (4) identifying and considering solutions to reduce turtle bycatch in longline fisheries; and (5) exchanging information and gaining a comprehensive understanding of the fishing methodologies and operations of national fleets.

The Workshop Steering Committee identified and invited 102 participants from 26 countries, including Australia, Brazil, Canada, Chile, Costa Rica, Ecuador, France, Federated States of Micronesia, Germany, Greece, Guatemala, Italy, Japan, Mexico, New Caledonia, Peoples Republic of China, Peru, Philippines, Portugal, Republic of Korea, Seychelles, South Africa, Spain, Taiwan R.O.C., United States of America, and Vietnam. Fifty-six participants from 20 countries attended, including Australia, Brazil, Canada, Costa Rica, Ecuador, France, Germany, Greece, Guatemala, Italy, Japan, Mexico, New Caledonia, Peoples Republic of China, Peru, Philippines, Portugal, Republic of Korea, Taiwan R.O.C., and United States of America.

The Workshop was divided into four topical sessions (see Agenda, page 11), each of which was followed by moderated plenary discussions. Written summaries of the oral presentations and the moderated plenary discussions are presented in this document. Following the oral portion of the agenda, participants broke out into four groups to discuss and formulate strategies and recommendations to address bycatch of sea turtles in longline fisheries. Each breakout group developed a series of recommendations for each of six strategies or key elements: (1) improved data collection; (2) regulatory approaches to fishery management; (3) incentives to participate in the development and implementation of bycatch reduction measures; (4) modifications of gear and fishing practices; (5) modifying, developing, and implementing multi-lateral agreements; and (6) training, outreach, and capacity building. These strategies and recommendations were synthesized into one integrated document. The document was presented during plenary and participants were asked to prioritize those recommendations they considered critical to reducing interactions between turtles and longline fisheries. For each of the six strategies, action items were categorized as “Highest Priority Actions,” “Priority Actions,” or “Actions.” The outcome of this exercise is summarized in the Executive Summary of the Workshop, also included in these Proceedings.

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EXECUTIVE SUMMARY

Participants from nineteen countries and four inter-governmental organizations (Food and Agriculture Organization of the United Nations - FAO, Inter-American Tropical Tuna Commission - IATTC, Convention on Migratory Species – CMS, Secretariat of the Pacific Community - SPC) participated at the International Technical Expert Workshop on Marine Turtle Bycatch in Longline Fisheries convened 11-13 February 2003 at Seattle, Washington, USA. Participants included individuals from government agencies, non-governmental and private organizations, industry, and academia.

Marine turtles are a global resource and their populations are impacted by numerous anthropogenic activities including degradation of nesting and foraging habitats, illegal poaching, overharvest of eggs, and incidental capture in commercial and artisanal fisheries. It is widely recognized that fisheries interactions comprise a significant threat to sea turtle populations. Among fisheries that incidentally capture sea turtles, certain types of trawl, gillnet, and longline fisheries generally pose the greatest threat. This Workshop focused on incidental capture of sea turtles in longline fisheries. The goal was to bring together academic, technical, and scientific expertise to discuss, develop and recommend actions to address global incidental capture in longline fisheries with the hope that implementation of these actions, where applicable, might reduce this particular threat.

The reduction of sea turtle bycatch in longline fisheries is one of many initiatives undertaken within the context of efforts to promote sustainable fisheries. Reducing waste, discards, bycatch, excess fishing capacity and eliminating illegal, unregulated, and unreported fishing are examples of the types of initiatives that contribute to a common goal as the international community seeks to improve and strengthen the regimes which govern sustainable use of global fisheries resources. Along with current conservation efforts to address other threats, these actions will contribute to global sea turtle conservation and recovery.

The Workshop objectives were: (1) to evaluate existing information on turtle bycatch in longline fisheries; (2) to facilitate and standardize collection of data from longline fisheries that are likely to interact with marine turtles; (3) to exchange information on experimentation with longline gear relative to turtles and target species; (4) to identify and consider solutions to reduce turtle bycatch in longline fisheries; and (5) to exchange information and gain a comprehensive understanding of the fishing methodologies and operations of global longline fleets.

Six overarching strategies were identified as key elements to address sea turtle bycatch in longline fisheries. These strategies are:

- Improved data collection and monitoring
- Regulatory approaches to fishery management
- Incentives to participate in the development and implementation of bycatch reduction measures
- Modifications of gear and fishing practices

- Modifying, developing, and implementing multi-lateral agreements
- Training, outreach, and capacity building

Specific actions were identified to implement each of these strategies taking into account the following: local, regional, and global scales; differences between developed and developing nations; differences in the biology and vulnerability of sea turtle species and stocks; and differences in the characteristics of longline fisheries. Because of the urgency of the sea turtle bycatch issue, both immediate and long-term actions were considered. Workshop participants prioritized actions to implement the six identified strategies outlined on the following pages.

The six highest-ranking actions overall are:

- Develop new approaches to time-area closures using real-time spatial management applied to all fleets to reduce marine turtle-longline fisheries interactions;
- Request that FAO convene an intergovernmental technical consultation to address the issue of marine turtle bycatch in longline fisheries;
- Encourage rapid deployment and implementation of gear and fishing practices that have shown promise for reducing marine turtle bycatch in shallow swordfish fisheries;
- Direct additional and immediate marine turtle bycatch reduction research in the major ocean basins to fine tune recent finding, taking into account differences among species;
- Involve industry in discussions regarding bycatch reduction strategies as early as possible;
- Identify and secure funding to accomplish these actions.

Taken together these actions constitute an initial policy approach for immediate action given the urgency of the need to reduce marine turtle bycatch and mortality in longline fisheries.

Strategy 1: IMPROVED DATA COLLECTION AND MONITORING

<u>Highest Priority Actions:</u>
- Identify and secure adequate funding to accomplish these actions.
- Collect information on sea turtle species and populations with regard to foraging and diving behavior, and distribution / movement patterns.
- Identify a coordinator and convene a technical working group/forum in regard to sea turtle bycatch in longline operations (both regionally and globally).
- Establish minimum standards for data collection for observer programs.
- Characterize longline fisheries, re-analyze existing data, identify data gaps and prioritize efforts in those areas.

<u>Priority Actions:</u>
- Implement minimum coverage observer programs or electronic monitoring systems (EMS) on longline fishing fleets for the purpose of data collection.

- Improve national collection and where relevant reporting to Regional Fishery Management Organizations (RFMOs) of catch and bycatch data.
- Develop monitoring programs to assess the success of gear and fishing modifications (e.g., pilot/small-scale observer programs, dockside interviews).

Other Actions:
- Undertake a consultation with fishermen from all fishing nations to get their input on factors leading to turtle bycatch and hot spots.
- Improve access and reporting in logbooks or other self reporting systems of catch, bycatch and fishing gear and methodology, recognizing the level of detail required to understand and be statistically significant for the longline bycatch issue (taking into account spatial, temporal and trip by trip variability).
- Develop a website clearinghouse for information, data standards, training, research programs.
- Establish a national/international register of vessels that fish using longlines;
- Develop partnerships and data sharing agreements with other focal groups (e.g., seabirds).

Strategy 2: REGULATORY APPROACHES TO FISHERIES MANAGEMENT

Highest Priority Actions:
- Develop new approaches to time-area closures using real-time spatial management applied to all fleets (e.g., identify high densities of turtles, migratory corridors, and critical habitat including ocean areas adjacent to nesting beaches).
- Encourage the dissemination of information and the promotion of fishing activities that minimize the bycatch of turtles through RFMOs or other appropriate regional bodies.
- Promote a scheme of regulation whereby individual vessels or fleets are encouraged or rewarded for particular activities or performance standards, such as number of turtle interactions.
- Regulate for basic data collection and compliance including observer, EMS, Monitoring, Control, and Surveillance (MCS), and boarding programs.
- Enact legislation, rules, or regulations to require the minimization of marine turtle fisheries interactions based on based available research and information on gear modification.
- Require turtle handling guidelines, standards, and attendance at turtle handling workshops.

Priority Actions:
- Cap fishing effort worldwide, reduce over-capacity, and harmful subsidies by working through RFMOs and cooperative organizations, with an emphasis on areas where sea turtle bycatch is highest.
- Ensure that regulations do not hinder conservation and research efforts by, where necessary, providing exemptions for protected species handling restrictions for fishermen who are contributing to research programs.

- Recommend that, where appropriate, national regulations stipulating that J-hooks of a certain size be used for all longline fishing be reconsidered in light of experimental results to date.
- Utilize multilateral trade measures to encourage compliance with fishery management regulations relevant to sea turtle bycatch.

Other Actions:
- Make the reporting of protected species bycatch in logbooks a mandatory requirement in all countries.
- Ensure conservation laws are applied both globally and equitably.
- Implement an international real time at-sea reporting system of sea turtle sightings based on fishermen information, other vessel data, tracking information and other reports.

Strategy 3: INCENTIVES TO PARTICIPATE IN THE DEVELOPMENT AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

Highest Priority Actions:
- Involve industry in discussions at earliest point possible.
- Develop gear exchange and training programs to encourage "turtle-friendly" fishing practices.
- Develop incentives or rewards for fishermen that participate in gear development or research programs.

Priority Actions:
- Where logistically applicable (e.g., large international fleets under RFMO regimes) reward fishers for low bycatch rates by, for example, allocating greater fishing quota, longer seasons, etc.
- Ensure that a portion of vessel licensing fees is applied to sea turtle conservation activities.
- Apply product import requirements, through relevant RFMOs, for non-compliance with agreed sea turtle conservation and management measures.

Other Actions:
- Assure anonymity for data sharing.
- Establish a competition among fishers for the development of best practices to reduce sea turtle bycatch in longline fisheries (e.g., BirdLife International model).
- Approach Marine Stewardship Council or other appropriate body about developing criteria for a dynamic certification program for the longline fishery.

Strategy 4: MODIFICATIONS TO GEAR AND FISHING TACTICS

Highest Priority Actions:

- Encourage rapid deployment and implementation of the following items that have shown promise for reducing bycatch in shallow swordfish fisheries:
  - Reduce daylight soak time for shallow set gear (has shown promise for loggerhead bycatch reduction)
  - Leaders longer than float line
  - Leaded swivels on leaders
  - Circle hooks
  - Turtle handling and gear removal (e.g., de-hookers, line cutters, etc.)
  - Mackerel baits - 500g for swordfish operations
  - Real time communication among and between fleets to avoid areas of high turtle densities.
- Direct additional and immediate research in the major ocean basins to fine tune recent findings, taking into account differences among species:
  - Effects of circle hooks on target species, i.e., improve catchability
  - Bait type and baiting techniques
  - Experiment with weighted leaders to reduce leatherback entanglement
  - Repellents – shark scent or profile
  - Branch line materials
  - Attractiveness of gear
  - Deep sets.
- Establish an international fund for longline bycatch mitigation experiments, to build on existing gear research, with an international technical group to coordinate these experiments. Included in this is addressing international funding sources to support such activities (e.g., Global Environment Fund).
- Increase research on post-hooking mortality.

Priority Actions:

- Promote sharing of information between gear engineers, gear suppliers, industry, and scientists on effectiveness of certain gear in reducing bycatch and impact on target catch levels, including results of gear experiments.
- Investigate the potential of alternative fishing methods particularly in artisanal fisheries and in coastal areas where sea turtle interactions are high.
- Develop gear modification for artisanal fisheries.
- Ensure that gear alterations intended to minimize the incidental capture of sea turtles do not have a detrimental impact on other non-target species.

Other Actions:
- Export trials/experiments to tuna and other target longline fisheries that use the "Japanese circle" hook and other hook variations.
- Communicate results of the Azores and U.S. Northeast Distant experiments to other regions via RFMOs.
- Coordinate networks for discussion of bycatch gear modification efforts.
- Ensure that bycatch reduction research evaluates target species catch rates.
- Foster a global environment where experimental fisheries can continue.
- Compare target and bycatch rates from various fisheries, including temporal and spatial variations.

Strategy 5: MODIFYING, DEVELOPING, AND IMPLEMENTING MULTI-LATERAL AGREEMENTS

Highest Priority Actions:
- Request that FAO convene an inter-governmental technical consultation to address marine turtle bycatch in longline fisheries, to consider the potential utility of an International Plan of Action (IPOA), and to call for submission and collection of data relevant to the longline sea turtle bycatch problem.
- Work through established RFMOs to promote marine turtle conservation (including, but not limited, to General Fisheries Commission for the Mediterranean - GFCM, International Commission for the Conservation of Atlantic Tunas - ICCAT, Indian Ocean Tuna Commission - IOTC, Inter-American Tropical Tuna Commission - IATTC, Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean - MHLC, Northwest Atlantic Fisheries Organization - NAFO).
- Continue efforts to address Illegal, Unregulated, and Unreported (IUU) fishing;
- Ensure regional and international agreements recognize non-target species.
- Integrate actions to reduce longline turtle bycatch into existing management bodies and multi-lateral agreements.
- Encourage countries to modify national reporting standards and/or enter into international data collection agreements.

Priority Actions:
- Develop a standing committee/taskforce (with coordinator) including participants from this group to continue momentum and ensure continuity into the future.
- Encourage all States/entities to sign or ratify relevant international agreements such as the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, U.N. Convention on the Law of the Sea/Fish Stocks Agreement, CMS, and the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC).

- Encourage both national and international authorities with responsibility for fisheries management and sea turtle conservation to coordinate with regard to the issue of sea turtle longline bycatch.
- Introduce specific ideas from this meeting into regional sea turtle conservation plans (i.e., IAC, Memorandum of Understanding (MoU) on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia - IOSEA, West African Memorandum of Understanding Concerning Conservation Measures for Marine Turtles, and Comisión Permanente del Pacifico Sur - CPPS).
- Ensure that special attention is given to developing countries when new agreements are negotiated.
- Introduce language on the incidental capture of sea turtles in fishing gear into a U.N. General Assembly resolution.

Other Actions:

- Use extant conservation agreements to create linkages between relevant sea turtle agreements (e.g., IOSEA MoU, West African MoU, IAC, and MoU on ASEAN (Association on Southeast Asian Nations) Sea Turtle Conservation and Protection) and other agreements that pertain to sea turtles (e.g., South Pacific Regional Environment Programme (SPREP), Barcelona Convention, and Bern Convention).
- Maintain existing momentum on the issue of sea turtle longline bycatch and maintain/expand existing networks including those established at this and previous meetings, such as the Marine Turtle Specialist Group (MTSG).
- Investigate a legal framework for bycatch reduction on the high seas.
- Actively engage fishing industry organizations in development of cooperative agreements (i.e., International Coalition of Fishing Organizations).
- Request that the IAC require reporting on bycatch from all fisheries.
- Free trade agreements should promote independent "turtle-safe" certification programs.
- Ensure that international agreements fulfill their mandates and that necessary resources are available.
- Identify a successful agreement/framework/model to base future agreements.

Strategy 6: TRAINING, OUTREACH, AND CAPACITY BUILDING

Highest Priority Actions:

- Provide necessary gear (e.g., de-hooking devices) to industry, and/or information on how fishermen can obtain gear and handling guidelines.
- Develop outreach materials for different regions, in multiple languages, for public, industry, and government officials:
    - Integrate longline issues in overall sea turtle conservation materials
    - Increase awareness of bycatch in general
    - Identify actions that can be taken, e.g., mitigation strategies and handling techniques

  - Incorporate public relations expertise, perhaps from non-governmental organizations (NGOs).
- Conduct workshops to train observers and fishers on proper turtle handling and release methods.
- Support developing countries by providing technical expertise, training opportunities, and financial assistance (including assistance funds from developed countries, e.g., Australian Government Overseas Aid Program - AusAID, Canadian International Development Agency - CIDA, Danish Cooperative for Environment and Development – DANCED) to implement sea turtle mitigation measures.
- Develop training/information kits to explain problems, solutions, and best practices that are tailored to appropriate audiences and updated with new information as it becomes available (consider providing on CD-ROM for ease of distribution).

Priority Actions:
- Promote cooperative research programs and scholarships for bycatch reduction research.
- Establish a training task force to target industry trade shows (e.g., Spain spring 2003, China fall 2003, FishExpo in Seattle each year) to disseminate information and to visit countries and establish in-country capacity to train and disseminate information to fisheries and resource managers and industry.
- Develop a website to provide information and results on bycatch reduction research, successful fishery management models for developing countries, and protocols for observer programs.
- Convene subsequent meetings of the International Fishers Forum (IFF) and expand participation to all ocean basins.
- Request all relevant international fisheries and conservation bodies to elevate the profile of the importance of the problem of sea turtle longline bycatch.
- Involve the range of gear manufacturers in gear modification research and development (and in the dissemination of information).
- Build national scientific capacity (e.g., graduate students, future leaders, NGOs).
- Provide information to industry, vessel owners, and import/export companies about the need and economic advantage of addressing longline sea turtle bycatch.
- Introduce sea turtle conservation and bycatch issues in fisher courses.

Other Actions:
- Communicate handling protocols and results of bycatch experiments in various forums (e.g., Marine Turtle Newsletter, CTURTLE listserve, Annual Sea Turtle Symposium).
- Use port visits as a means of data collection, training, and outreach with fishers.
- Develop “lobbying” documents for national and international programs for decision makers and general public.
- Encourage and publicize the utility of rescue centers and stranding networks.
- Build capacity for development of legal frameworks to address sea turtle bycatch.

- Highlight the important role NGOs play with respect to outreach and funding.
- Promote interagency communication within governments
- Introduce the problem of marine turtle bycatch to NGOs that are not currently engaged in the issue.

ACKNOWLEDGMENTS

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WORKSHOP AGENDA

DAY 1: TUESDAY, FEBRUARY 11, 2003

7:00 - 8:00 Continental Breakfast at Aljoya Conference Center

Plenary Sessions (Cedar Room)

8:00 - 8:15 Welcome **Rebecca Lent -** Deputy Assistant Administrator for Fisheries - NOAA/NMFS

8:15 - 8:30 Workshop Logistics

OVERVIEW OF GLOBAL LONGLINING (Chair: Martín Hall - Inter-American Tropical Tuna Commission)

8:30 - 11:00 PART I: GLOBAL AND SEASONAL DISTRIBUTION AND EFFORT, GEAR CONFIGURATION, TARGET SPECIES, and EFFORT TRENDS

- **8:30 - 9:00** Pacific Ocean
  Peter Williams - Secretariat of the Pacific Community

- **9:00 - 9:30** Indian Ocean
  Robert Campbell - Commonwealth Scientific and Industrial Research Organisation, Australia

- **9:30 - 10:00** Coffee Break

- **10:00 - 10:30** Atlantic Ocean
  Gerry Scott - U.S. National Marine Fisheries Service

- **10:30 - 11:00** Mediterranean Sea
  Antonio di Natale - AQUASTUDIO

- **11:00 -12:00** Moderated Discussion

12:00 - 1:00 LUNCH at Aljoya Conference Center (Pacific Dining Room)

1:00 - 2:00 PART II: EXISTING REGULATORY REGIMES
David Hogan - Office of Marine Conservation, U.S. Department of State

2:00 - 3:00 Moderated Discussion

3:00 - 3:30 Coffee Break

OVERVIEW OF MARINE TURTLES AND LONGLINE FISHING (Chair: Earl Possardt - U.S. Fish and Wildlife Service)

3:30 - 4:00 Global Population Status of Marine Turtles
Colin Limpus[1] and **Peter Dutton**[2]- [1]Queensland National Parks and [2]U.S. National Marine Fisheries Service

4:00 - 4:45 Global Overview of Incidental Capture of Marine Turtles in Longline Fisheries
Rebecca Lewison - Duke University Marine Lab

4:45 - 5:30 Moderated Discussion

6:00 - 8:00 Reception at Aljoya Conference Center (Pacific Dining Room)

DAY 2: WEDNESDAY, FEBRUARY 12, 2003

7:00 - 9:00 Continental Breakfast at Aljoya Conference Center

Plenary Session (Cedar Room)

BYCATCH REDUCTION RESEARCH (Chair: Carolyn Robins - Belldi Consultancy, Australia)

9:00 - 9:20 U.S. NW Atlantic Ocean - **John Watson** - U.S. National Marine Fisheries Service

9:20 - 9:40 U.S. Central Pacific - **Christofer Boggs** - U.S. National Marine Fisheries Service

9:40 - 10:00 Azores - **Alan Bolten** - University of Florida

10:00 - 10:30 Coffee Break

10:30 - 10:50 Behavioral Research to Evaluate Potential Deterrents - **Richard Brill** - U.S. National Marine Fisheries Service

10:50 - 11:10 Techniques for Evaluating the Distribution and Movements of Marine Turtles in Relation to Longline Fishery Operations - **Jeffrey Polovina** - U.S. National Marine Fisheries Service

11:10 - 11:30 Seabird Bycatch Reduction Research and Implementation of Bycatch Reduction Measures - **Kim Rivera** - U.S. National Marine Fisheries Service

11:30 - 12:00 Moderated Discussion

12:00 - 1:00 LUNCH at Aljoya Conference Center (Pacific Dining Room)

1:00 - 1:30 Synthesis of Results/Outcomes from the Second International Fishers Forum - **Christofer Boggs** - U.S. National Marine Fisheries Service

BREAKOUT GROUP SESSIONS

1:30 - 3:00 Breakout Groups - four breakout groups will convene to discuss and formulate strategies and recommendations to address bycatch of sea turtles in longline fisheries (Maple, Alder, and Cedar Rooms)

3:00 - 3:30 Coffee Break

3:30 - 5:00 Breakout Groups Continue (Maple, Alder, and Cedar Rooms)

DAY 3: THURSDAY, FEBRUARY 13, 2003

7:00 - 8:30 Continental Breakfast at Aljoya Conference Center

8:30 - 9:00 Plenary (Cedar Room)

9:00 - 10:15 Breakout Groups Continue (Alder, Lodge, and Cedar Rooms)

10:15 - 10:30 Coffee Break

10:30 - 12:00 Breakout Groups Complete Work (Alder, Lodge, and Cedar Rooms)

12:00 - 1:00 LUNCH at Aljoya Conference Center (Pacific Dining Room)

1:00 - 5:00 Plenary Session (Cedar Room)

WORKSHOP AGENDA (continued)

1:00 - 2:45 Breakout Groups report back to the plenary for feedback and discussion

2:45 - 3:00 Coffee Break

3:00 - 5:00 Discussion/Recommendations integrated and synthesized into Workshop report

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LIST OF ACRONYMS

ACCSTR	Archie Carr Center for Sea Turtle Research
ALB	Albacore tuna
ASEAN	Association of Southeast Asian Nations
BET	Bigeye Tuna
BFT	Bluefin Tuna
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CCL	Curved Carapace Length
CPPS	Comisión Permanente del Pacifico Sur
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CITES	Convention on the International Trade of Endangered Species
CMS	Convention on Migratory Species
COFI	Committee on Fisheries
CPUE	Catch Per Unit Effort
DOP	Department of Oceanography and Fisheries
DWFN	Distant Water Fishing Nations
EC	European Commission
ECC	Equatorial Counter Current
EEZ	Exclusive Economic Zone
EPO	Eastern Pacific Ocean
ERG	Electroretinographic
ESA	U.S. Endangered Species Act
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization
F/V	Fishing Vessel
GATT	General Agreement on Tariffs and Trade
GFCM	General Fisheries Commission for the Mediterranean
GFST	Gulf Stream
GRT	Gross Registered Tons
HPB	Hooks Per Basket
HST	Hawaii Standard Time
IAC	Inter-American Convention for the Protection and Conservation of Sea Turtles
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission on the Conservation of Atlantic Tuna
IFF	International Fishers Forum
IFF2	2nd International Fishers Forum
IPOA	International Plan of Action
IOSEA	Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia
IOTC	Indian Ocean Tuna Commission
IUCN	World Conservation Union

IUU	Illegal, Unreported, and Unregulated
IW	Integrated Weight
KEC	Kuroshio Extension Current
LED	Light Emitting Diode
LOA	Length Overall
MAB	Mid-Atlantic Bight
MARPOL	International Convention for the Prevention of Pollution from Ships
MHLC	Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
MOU	Memorandum of Understanding
MtDNA	Mitochondrial DNA (deoxyribonucleic acid)
MT	Metric Ton
MTSG	Marine Turtle Specialist Group
NAFO	Northwest Atlantic Fisheries Organization
NEC	North Equatorial Current
NED	Northeast Distant area
NEI	Not Elsewhere Included
NEPA	U.S. National Environmental Policy Act
NGO	Non-Governmental Organization
NMFS	U.S. National Marine Fisheries Service
NPOA	National Plan of Action
NPST	North Pacific Subtropical Gyre
NPTG	North Pacific Tropical Gyre
NWCS	Northwest Atlantic Continental Shelf
OR	Olfactory Receptor
PNG	Papua New Guinea
RFMO	Regional Fisheries Management Organization
SCL	Straight Carapace Length
SCRS	Standing Committee on Research and Statistics
SEAFDEC	Southeast Asian Fisheries Development Center
SKJ	Skipjack Tuna
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environmental Program
SST	Sea Surface Temperature
TDR	Time-Depth Recorder
TED	Turtle Excluder Device
TJK	Taiwan, Japan, and Korea
TZCF	Transition Zone Chlorophyll Front
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea

LIST OF ACRONYMS (continued)

VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Convention or MHLC
WCPO	Western Central Pacific Ocean
WIDECAST	Wider Caribbean Sea Turtle Conservation Network
WTO	World Trade Organization
YFT	Yellowfin Tuna

OVERVIEW OF GLOBAL LONGLINING

PART I: GLOBAL AND SEASONAL DISTRIBUTION AND EFFORT, GEAR CONFIGURATION, TARGET SPECIES, AND EFFORT TRENDS

ORAL PRESENTATIONS
AND
MODERATED DISCUSSION

OVERVIEW OF LONGLINING IN THE PACIFIC OCEAN

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For the purposes of compiling information from the Pacific Ocean tuna fisheries, the Pacific Ocean is divided into two broad areas, the Pacific Ocean west of 150°W (the western and central Pacific Ocean - WCPO) and the Pacific Ocean east of 150°W (the eastern Pacific Ocean - EPO), with responsibilities for each currently resting with the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC) and the Inter-American Tropical Tuna Commission (IATTC), respectively.

Much of the WCPO, particularly in the equatorial band between 20°N-20°S, comprises the exclusive economic zone (EEZ) waters of Pacific island and Pacific-rim countries. In contrast, most of the EPO constitutes international waters.

Longline is one of three main fishing gears targeting tuna species throughout the Pacific, the other primary gears being purse seine and pole-and-line. Longline takes only 1-15% of the total tuna catch in the pacific, the majority coming from the purse seine fishery, but the longline fishery rivals the purse seine fishery in the value of the landed catch.

The tropical and sub-tropical longline fleets of the Pacific Ocean predominately target adults of three species of tuna, bigeye, yellowfin, and albacore. The tuna-target fisheries are divided into two broad categories:

- The **distant-water** fleets are comprised of large vessels (typically >250 gross registered tonnes (GRT)), with on-board facilities to freeze and store their catches, enabling them to undertake long voyages (of typically several months) fishing over wide areas. They target either tropical (yellowfin, bigeye) or sub-tropical (albacore) tuna species with most vessels flagged in Japan, Korea, and Taiwan to service the frozen sashimi market.
- The **offshore** fleets are comprised of vessels that are relatively smaller in comparison (<100 GRT), have "ice" or "chill" capacity, and serve the fresh sashimi markets. These vessels make much shorter voyages, typically around 2-3 weeks. They target yellowfin and bigeye in tropical areas and albacore in sub-tropical waters. It has been convenient to define sub-categories of the offshore fleet category, which include:
    - "Domestic fleets" essentially fish in and around their home waters. Examples of this type of fleet include the Japan coastal and Taiwanese domestic longline fleets and fleets from Australia, Hawaii, New Zealand, and many Pacific Island countries.

- "Foreign fleets based out of Pacific island member countries" include the Japanese, Taiwanese, and mainland Chinese offshore fleets based out of Micronesian countries in the western and central Pacific Ocean.

While tuna are by far the predominant target species of longline vessels in the Pacific Ocean, there are other important non-tuna target fisheries in the Pacific Ocean. The most significant non-tuna target fishery category is the swordfish target fishery that exists in several areas of the Pacific Ocean. These vessels target swordfish using special fishing techniques and strategies (e.g., set gear shallow and use "light sticks"). They operate in certain areas of the Pacific (i.e., sub-tropical temperate waters) where swordfish are more readily available to longline gear.

Non-tuna target fisheries other than swordfish include several shark-target fisheries that exist in certain areas of the Pacific Ocean. Shark-target fisheries comprise a very minor proportion of the overall longline effort where they exist in the WCPO and tend to be highly regulated. However, in some Latin American countries, shark-targeting is understood to be significant. While information is generally not as complete as for the tuna-target fisheries, longline fisheries that target species other than tuna and swordfish are understood to account for only a few percent (at best) of the total longline effort in the Pacific Ocean.

The Pacific Ocean longline fishery has evolved considerably over the past 40-50 years. Prior to the 1950s, effort was predominantly by Japanese longline vessels operating in the western region of the Pacific Ocean. During the 1950s, there was further expansion of the Japanese fishery into the Pacific as distant-water vessels and the Korean fleet and domestic Taiwanese fishery were established. The US longline fleet was also active, but the Japanese were easily responsible for most of the Pacific Ocean longline effort. During the 1960s, there was further expansion of the distant-water fleets from Japan, Korea, and Taiwan; these fleets primarily targeted yellowfin over bigeye in the tropical/sub-tropical waters. During the 1970s, other Pacific island and Pacific-rim countries showed interest in entering the Pacific Ocean longline fishery, although for most fleets, this did not happen until the 1980s/1990s. Toward the end of the 1970s, there was a significant development in the tropical/sub-tropical longline fishery with the gradual change in targeting bigeye over yellowfin as a result of the higher prices commanded for bigeye. Longline vessels were now fishing deeper by setting more hooks between floats in order to better target the depth where bigeye tuna were understood to be more "available".

Over the period from 1950 to 1980, there was a steady increase in total longline effort. Since 1980, effort has stabilised with economics playing more of a role in restricting the fishery. During the 1980s and 1990s, more domestic fleets were established, which exploited tuna resources in home waters. Some fleets that entered the fishery over this period found it difficult to compete for one reason or another and were subsequently forced out.

A significant development in recent years had been the decline in the number of distant-water vessels, particularly from Japan, mainly due to economics (e.g., lower profit margins as a result of increasing operating costs). During the early-mid 1990s, there was an influx of small

Taiwanese and mainland Chinese offshore vessels into Micronesian countries. A few years later, there was a corresponding decline in vessel numbers due to the economics of running vessels, as well as related fishing capabilities (or lack thereof) of certain vessels in these fleets. In contrast, there has been a gradual increase in the number of Pacific island vessels over the past 8-10 years. Significant domestic longline fisheries now exist in Fiji, Samoa, American Samoa, and French Polynesia.

Longline effort is distributed throughout the entire Pacific Ocean, with most effort concentrated in the equatorial band from 20°N-20°S. Distant-water fleets fish the widest area of the Pacific Ocean, covering large portions of the high seas, particularly the central and eastern areas of the Pacific. Foreign offshore fleets (essentially Japan, Taiwan, and mainland China) almost exclusively fish in the waters of Micronesian countries (Federated States of Micronesia, Palau, and the Marshall Islands). Domestic offshore fleets are very much confined to the EEZs of Pacific-rim and Pacific island countries.

Longline vessels in the pacific Ocean can be further categorised in terms of the target species and the methods they use to target these species. Most pelagic longline effort in the Pacific can be put into one of the three following general categories of targeting.

Conventional tuna targeting easily accounts for the largest number of vessels throughout the Pacific Ocean. They typically set more than 9 hooks between floats, although this varies depending on area fished, fleet, and other characteristics. They soak their gear during the day or night, and the bait used varies, again dependent on area fished and fleet. These fleets target bigeye and yellowfin in warm tropical waters and albacore, bluefin, and southern bluefin in more temperate waters.

In contrast, some vessels target tuna using a shallow-set strategy. These vessels set only 4-5 hooks between floats and soak their gear during the night, concentrating fishing effort in the week leading up to the full moon. Bait varies, although it is fleet-dependent to some degree. This category is essentially comprised of Taiwanese and mainland Chinese fleets targeting bigeye and yellowfin in the waters of Micronesian countries.

The third major category comprises those vessels that primarily target swordfish. These vessels typically set 4-6 hooks between floats. Soak time is generally during the night and light sticks are attached to the gear to help attract the swordfish. The bait used is almost exclusively squid. In contrast to tuna-target effort, swordfish-target effort is restricted to sub-tropical/temperate waters in the north and south Pacific Ocean.

The distribution of the longline catch by target species provides a broad indication of the relative magnitude in effort and the strategies involved in Pacific Ocean longline fisheries. Most bigeye tuna are taken in the equatorial band bounded by 20°N-20°S, although there are also significant numbers taken in more temperate-water fisheries (e.g., Hawaii and to the east of Japan, and seasonally in some Pacific Island countries, such as Fiji and New Caledonia). Bigeye are the most predominant species of the longline target catch in the well-known eastern Pacific longline fishery. In contrast, yellowfin are the most predominant species of the longline target catch in the western equatorial areas of the Pacific Ocean. Like bigeye, most of the Pacific Ocean yellowfin catch is taken in the area bounded by 20°N-20°S. Albacore are rarely taken in tropical waters and are the main component of the catch in most sub-tropical and temperate waters of the north and south Pacific Ocean. Swordfish are taken primarily in target fisheries in the more temperate waters of both hemispheres of the Pacific. Significant swordfish fisheries exist in the waters to the east of Japan, in and around Hawaiian waters, and off the east coast of Australia. Swordfish are also taken as bycatch throughout the Pacific Ocean, notably in the eastern Pacific fishery targeting bigeye. Juveniles make up most of the swordfish taken as bycatch in the western equatorial areas and these are often discarded, since they have no commercial value.

Stock assessment work has until now concentrated on the target tuna species taken in the longline fisheries. Researchers continue to develop procedures in an attempt to account for effects of changes in targeting as well as the variation in environmental parameters that define the preferred habitats of each tuna species. Researchers use information on the biology, behaviour, and physiology of tuna species in conjunction with oceanographic characteristics (e.g., water temperature and oxygen concentration in the water by depth) to get a better appreciation of the "preferred" habitat of each species. Given an indication of the "preferred" habitat of a species, one can then get an idea of which hooks in the set are likely to be more effective than others. The depth targeted by fishing vessels has certain implications on the type and magnitude of bycatch taken in the fishery, which has also become the focus of certain research work in recent years. A great deal of work is currently directed at improving our knowledge in this area, for example, the increased use of archival tags.

Questions and Discussion

Question: What is the status of fish aggregating devices (FADs) and how does this affect marine turtle bycatch?

Response: There has been a drastic increase in the use of FADs in the purse seine fishery in the past 5-7 years. The Secretariat of the Pacific Community (SPC) has noted that there has been a large catch of juvenile bigeye tuna and that bycatch is generally higher with the use of FADs. Due to the La Niña conditions, there are fewer logs and fishermen are relying more heavily on FADs in distant areas of the Western and Central Pacific Ocean (WCPO). This is an important area for future research and analysis of existing data.

OVERVIEW OF LONGLINING IN THE INDIAN OCEAN

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Introduction

Like the other major oceans of the world, the Indian Ocean supports a diversity of large and small-scale fisheries, which catch tuna and tuna-like species. The total reported catch of tuna and billfish in the Indian Ocean first exceeded one million metric tonnes(t) in 1993 and totaled 1.2 million t in 2000. While large scale industrial longline and purse seine fleets operate in the region, the Indian Ocean differs from other oceans in that artisanal fisheries have historically taken nearly as much as industrial fisheries. However, while the distant water fishing nations (DWFNs) target tropical and temperate oceanic tunas and, to a lesser extent, swordfish, neritic species predominate in most coastal country catches (except for Maldives, Sri Lanka, and Indonesia). Artisanal fisheries use gill nets, troll and hand lines, and pole-and-line gears to target tuna and tuna-like species. Their importance has increased significantly in recent years and artisanal craft are ranging over progressively larger areas.

Longlining started in 1952 in the eastern Indian Ocean, and by the mid-1970s had spread over most of the ocean. In recent years the total reported longline catch has been around 250,000 tonnes annually. Of the industrialised fishing methods, fish caught by longline gear have the highest value as large fish are caught, much of which goes to the high priced sashimi market. On the other hand, most of the catch taken by industrial purse seining (which started in the early 1980s and now produces nearly 360,000t annually) is destined to the canned fish market at relatively low prices. Canning, however, is an important activity in a number of Indian Ocean countries, including Thailand, Seychelles, Mauritius, and Madagascar.

During 2000, industrial longline and purse seine fishing accounted for 21 and 38 percent of the total catch of tunas, respectively, with gill nets and bait boats accounting for another 21 and 9 percent respectively. However, the catch of billfish during 2000 was dominated by the longline catch (59 percent) with gill nets accounting for a further 36 percent.

This paper provides a general overview of longline fishing effort in the Indian Ocean. After an initial overview of the main longline fishing nations, the associated catches and target practices, the discussion focuses on the annual level of longline effort, and the spatial distribution of this effort by quarter, for those fleets for which data exists. Some information on gear configurations is also given.

An estimate is also made of the total annual effort for all fleets where data does not exist. Finally, some data on the catch of turtles by longline fleets operating in the Indian Ocean is also presented.

Data Sources

The data on which the information presented in this overview is based was sourced from the Indian Ocean Tuna Commission (IOTC), which collates the catch and effort data pertaining to fishing for tuna and billfish in the Indian Ocean. The data collected and reported by the IOTC are of various quality and the reader is referred to the IOTC website (www.iotc.org) for a full description of the data and their quality. In particular, an overview of the data collected is provided in the latest data summary (Anon 2002a) while a report on the general status and quality of the data is given in Anon (2002b).

The particular data used for this review are taken from the following two public domain data files available from the IOTC website:
1) Nominal Catch, which lists the annual catches by species in live weight equivalent within two IOTC statistical areas (corresponding to the eastern and western Indian Ocean) aggregated by fishing gear and fleet flying the flag of the reporting country; and
2) Catch and Effort, which lists catch in weight and/or numbers of fish and associated fishing effort by month, species, and gear.
The data were obtained in May 2002.

Overview of Total Catch and Longline Fleets

The total catch of tuna and tuna-like species reported by fishing method since 1950 within the Indian Ocean is shown in Figure 1. Total reported catch has increased from around 25,000 tonnes in 1950 to 1.5 million tonnes in 2000. The reported catch of tunas (comprising the catch of albacore, bigeye, bullet, frigate, longtail, southern bluefin, skipjack, yellowfin, and kawakawa tuna) represents around 75 percent of this total, with billfish (black, blue and striped marlin, sailfish, short-billed spearfish, and swordfish) comprising 5.3 percent of the total, seerfish (including narrow-barred Spanish mackerel, king mackerel, wahoo, and streaked seerfish) comprising 12.4 percent, sharks 4.7 percent and other non-tuna or tuna-like species (which are likely to be highly underestimated) comprising 2 percent.

The annual increase in total reported catch displays two distinct phases. Between 1950 and 1982, when the fishery was dominated by longline and other gears, the total catch increased at an annual rate of around 12,000t, with the total catch first exceeding 400,000t in 1982. However, with the large increase in the use of gillnet and industrial purse-seine fisheries after 1982 the total catch has increased at an annual rate of around 60,000 t per annum.

The reported catch taken by longline gear averaged around 40,000t during the 1950s, increasing to 104,500t during the 1960s, with a peak catch of 166,000t taken in 1968. Between 1970 and 1985 the total longline catch remained relatively stable, with the annual catch varying between 90,000 and

132,000t and averaging around 109,000t. After the mid-1980s the total longline catch increased steadily, peaking in 1993 with a catch near 351,000 t. The average catch during the 1990s of 282,000t was also a significant increase on the catches taken before that time. Despite the increase in total longline catch over the years, the longline catch as a proportion of the total catch taken by all gears has decreased from around 50 percent in the 1950s and 1960s to less than 25 percent over the last two decades.

Since 1996, a total of 21 longline fleets from various coastal or DWFNs have reported catches taken within the Indian Ocean. A listing of these fleets, together with the total catch of all tuna and tuna-like species reported between 1996 and 2000, is shown in Table 1. Estimates of the catches taken by an additional three non-reporting (or NEI, Not Elsewhere Included) longline fleets are also shown. NEI-Ice and NEI-Indonesian Ice refers to small, fresh-tuna longliners operating under various flags, mainly from Taiwan, China. Fishing operations for these fleets concentrate within two main regions of the Eastern Indian Ocean, depending on the monsoon: 0-10ºS and 80-100ºE between October and March and 0-10ºS and 80-100ºE between April and September (M. Hererra, *pers. comm*). Catches are estimated by the IOTC from various sources, including sampling programs and historical information from plant operators. NEI-Deep Freezing (DRFZ) refers to the catches of non-reporting longline vessels, estimated by the IOTC using, in most cases, the number of vessels operating per year. Most of these vessels are former Taiwanese longliners changing flag (to, for example, Honduras, Belize, Panama, or Equatorial Guinea), but remaining under Taiwanese ownership. They are believed to operate in similar regions as the main Taiwanese fleet (M. Herrera, *pers. comm*).

Table 1 illustrates that over fifty percent of the total reported catch taken by longline vessels in the period 1996-2000 has been taken by only two fleets, Taiwan and Indonesia, with Taiwanese vessels alone taking around 32 percent of the total. Furthermore, only five fleets account for ninety percent of the total catch. DWFNs account for the majority, around three quarters, of the total catch, with only Indonesia and Reunion being in the top ten fishing fleets by catch. Unlike the more dominant role played in the other oceans, Japanese vessels account for only around 12 percent of the total annual catch.

For statistical reporting purposes, the IOTC divides the Indian Ocean into two regions - eastern and western, with the division running along the 77°E meridian from the tip of India to the equator, and then further south along the 80°E meridian. Table 1 indicates that the total longline catch taken in the Indian Ocean between 1996 and 2000 was equally divided between the western and eastern sides of the ocean, with on average, around 133,000t taken in each half each year. However, during 2000, 65 percent of the total tuna catch was caught in the western Indian Ocean, while the majority (53 percent) of the total billfish catch was taken in the eastern side. The time series of catches taken by each of the major fleets between 1990 and 2000 in each part of the Indian Ocean is shown in Figure 2. Apart from a large catch of around 250,000t taken in the western Indian Ocean in 1993, the longline catches in each part of the Indian Ocean show a general increase over this period. Taiwanese, NEI-DRFZ, and Japanese fleets dominate the catch in the western half of the Indian Ocean, while Indonesian, Taiwanese, and NEI-Ice fleets account for the majority of the catch taken in the eastern half.

A breakdown by the main species groups of the total catch reported by each fleet between 1996-2000 is shown in Table 2. Yellowfin and bigeye tuna each comprise around one-third of the total catch across all fleets, with albacore tuna and broadbill swordfish each comprise around 10 percent. The four main tuna species indicated together with swordfish comprise around 92 percent of the total catch, with another 5.5 percent consisting of other billfish. Taking those species which comprise 20 percent or more of the total catch as an indication of a target species of each fleet, the main DWFNs are mainly targeting yellowfin and bigeye tuna. Albacore tuna and swordfish are seemingly secondary target species for Taiwanese vessels, while southern bluefin tuna is a secondary target species for the Japanese fleet. Of the other longline fleets, yellowfin tuna and swordfish are seen to be the main target species, though bigeye tuna and other billfish species are also important for some fleets.

Annual Trends and Seasonal Distribution of Longline Effort

Of the 24 longline fleets which have reported a catch since 1996, thirteen fleets have also reported information on associated effort. However, no effort information is available for some of the major longline fleets, principally Indonesia and the NEI fleets. In this section, an overview of the annual trends and the spatial distribution of effort for those fleets for which data are available is presented.

Note: In the analysis of the effort data it was noticed that the associated total annual catch did not correspond to that reported in the Nominal Catch data. It is understood that this discrepancy is due to the fact that the coverage of effort for any fleet (which is based on logbook data) is not complete and that the effort data has not been raised as has the Nominal Catch data. An estimate of the data coverage in the Catch/Effort data was obtained by expressing the total catch in this data for a given fleet in a given year as a percentage of the total catch reported for that fleet and year in the Nominal data. In the Catch/Effort table the Japanese catch is only reported in number of fish. In order to obtain an estimate of catch in weight the average weight of fish caught in any year was assumed to be the same as that caught by the Taiwanese. Before 1967 the average weight of fish over the five years 1967-71 was used. A similar assumption was also made for the Korean catch for the years prior to 1994. The time-series of annual coverage for the Taiwanese, Japanese, and Korean fleets, shown in Figure 3, vary significantly over time. For the Japanese and Taiwanese fleets the coverage is generally greater than 60 percent and in recent years has been above 80 or 90 percent. The reasons for the coverage rate exceeding 100 percent for several years remains unclear. On the other hand, coverage rates for the Korean fleet for most years is less than 50 percent. Due to the fact that it is difficult to raise the effort data, as no information on coverage rates is available either by area or month, the temporal and spatial effort summaries reported in this and subsequent sections are based on the nominal or unraised effort data. As such, the reader should be mindful that the nominal effort might be an underestimate of the actual effort deployed in any year.

Taiwan

Taiwan vessels comprise the main longline fleet operating in the Indian Ocean, accounting for around one-third of the total reported catch between 1996 and 2000. This increases to more than half the total catch if one includes the Taiwanese vessels currently included in the NEI fleets described above. Although Taiwanese longliners have operated in the Indian Ocean since 1954, the time-series of longline fishing effort reported by the main Taiwanese fleet is only available since 1967 and is shown in Figure 4. Reported effort was generally below 50 million hooks up until the late 1970s, after which time effort has steadily increased, reaching over 250 million hooks in 1998 and 1999. Longline effort averaged around 230 million hooks between 1994 and 1998. The distribution of Taiwanese longline effort is seen to be relatively consistent across each quarter of the year (Figure 4), though slightly less effort occurs during the first quarter (accounting for around 22 percent of the annual total). Also shown in Figure 4 is the estimated level of non-reported effort based on the coverage levels discussed above. Total effort is estimated to have reached over 400 million hooks in 1993, declined to around half this level in 1997, then increased to around 275 million hooks in the late 1990s. The estimates of total effort also displays a more gradual increase in effort after the mid-1980s, unlike the dramatic doubling of effort reported between 1992 and 1993.

The mean spatial distribution of the reported annual catch of the main species taken between 1994 and 1998 (when coverage rates averaged 93 percent) is shown in Figure 5, and indicates that Taiwanese vessels generally fish in the western half of the Indian Ocean with very little fishing occurring east of 95°E. Distinct latitudinal differences in the main catch species are also seen. Large numbers of yellowfin tuna are taken in the north-western corner of the Indian Ocean, while bigeye tuna (together with yellowfin tuna and swordfish) dominates the catch in a band extending 10-degrees on either side of the equator. Below 10°S, albacore tuna generally dominates the catch, though equal portions of the main species are taken in the south-western corner of the Indian Ocean in a region just south of the Mozambique Channel.

The mean spatial distribution of quarterly fishing effort fleet between 1994 and 1998 for the main Taiwanese fleet (Figure 6) indicates distinct seasonal shifts in the location of fishing effort. During the first quarter (Jan-Mar), fishing effort is concentrated in the north-west region and within the equatorial band described previously. During the second quarter (Apr-Jun) effort remains concentrated in the north-west region but there is a significant decrease in effort in the southern equatorial band, with effort becoming concentrated in a region just south of the Mozambique Channel and within a temperate band between 30-40°S. The concentration of effort in these southern regions continues during the third quarter (Jul-Sep), but effort shifts away from the north-western corner becoming more dispersed within a central equatorial region. Finally, during the fourth quarter (Oct-Dec) effort shifts away from the southern regions and becomes concentrated within the broad band between 10-20°S.

Little information is currently available on the gear configurations used by Taiwanese vessels, though given the seasonal shifts in the spatial distribution of fishing effort and variations in catch compositions by latitude (and no doubt season) it would appear that a range of targeting practices are used. Information provided to the IOTC Working Party on Tropical Tunas indicates that Taiwanese vessels set between 7 and 18 hooks between buoys, but the relative proportions of each gear setting remains unknown.

Japan

Of the DWFNs, the Japanese longline fleet has the longest history of fishing within the Indian Ocean, having commenced fishing in the eastern Indian Ocean in 1952. By the mid-1970s, fishing effort had spread over most of the ocean. The time series of reported Japanese fishing effort is shown in Figure 7 and indicates that effort increased rapidly during the 1950s and 1960s, with reported effort reaching over 120 million hooks by 1967. Since this time, reported fishing effort has fluctuated in a significant manner, twice declining to less than half the 1967 peak before again increasing to similar levels. On the other hand, apart from the peak year in 1967, the estimates of total effort remain relatively constant until the mid-to-late 1970s, after which time there is a large increase to around 230 million hooks followed by a large decline to around 50 million hooks in 1993. Since the mid-1990s fishing effort has been relatively high compared to the historical trends, with reported effort levels averaging around 113 million hooks per annum. Between 1995 and 2000 fishing effort was generally evenly split across the second, third and fourth quarters (26-28 percent), with the first quarter accounting for around 19 percent of total annual effort. The level of unreported effort also appears to have decreased significantly in recent years.

The distribution of annual effort within each 10-degree band of latitude across the Indian Ocean is shown in Figure 8. During the 1950s Japanese longline effort was mainly confined to the band 10°N-20°S, but fishing effort expanded into the more southern region during the 1960s as the fishery continued to grow. After 1967, an increasing proportion of the annual effort was focused south of 40°S as the fishery concentrated on fishing for high quality southern bluefin tuna. By the late 1970s over half of the total effort was located south of 40°S, with three-quarters of the total effort occurring south of 30°S. While these changes coincided with a decrease in overall effort between 1967 and 1980 (Figure 7), the proportion of total effort south of 30°S remained high (around 70 percent) as total effort increased during the 1980s back to previous high levels. After 1989 there was a sharp decrease in the proportion of effort south of 30°S and a corresponding increase in the proportion in the region to the north bounded by 10-30°S. By the mid-1990s, the proportion of total effort south of 30°S had declined to around 25 percent. This change is likely to have been influenced by the restrictive quotas placed on the catch of southern bluefin after 1988, and again coincides with a general decrease in overall Japanese longline effort throughout the Indian Ocean. Since 1996 the proportion of effort within each of the latitudinal bands has remained relatively constant, with the majority of effort (56 percent) during this period occurring between 10-30°S.

The mean spatial distribution of the reported annual catch of the main species taken between 1996 and 2000 (when coverage rates averaged 95 percent) is shown in Figure 9, and indicates that Japanese catch has both a more widespread and concentrated distribution than the Taiwanese catch. However, like the Taiwanese catch, distinct latitudinal differences in the main catch species are also seen. While yellowfin tuna are main species taken in the western equatorial regions and within the

Mozambique Channel, a mix of species is taken in the region south of this Channel and within the south-western corner of the Indian Ocean. Southern bluefin tuna is the dominant catch species in the region south of 40°S in the west. In the eastern Indian Ocean, bigeye tuna is generally the dominant catch species in the regions north of 35°S, while southern bluefin tuna dominates the catch south of this line.

The mean spatial distribution of quarterly fishing effort between 1996 and 2000 for the Japanese fleet is shown in Figure 10, and again indicates distinct seasonal shifts in the location of fishing effort, though not to the same extent as the Taiwanese fleet. During the first quarter, effort is spread across the Indian Ocean north of 35°S, with effort concentrated within several widely scattered regions, especially in the Mozambique Channel. During the second quarter, effort shifts south of 40°S to target southern bluefin tuna, though several areas of concentrated effort remain spread across the Indian Ocean, particularly south of the Mozambique Channel and Madagascar and around the Seychelles. Japanese longline effort is concentrated in two main regions during the third quarter - in the south-western and south-eastern corners of the Indian Ocean and generally south of 35°S, with a smaller amount of effort remaining concentrated in the equatorial region. Finally, during the fourth quarter, a large amount of effort remains concentrated in the south-eastern corner of the Indian Ocean (targeting southern bluefin tuna), with effort shifting back into the Mozambique Channel and across the equatorial regions.

Before the practice of setting deeper longlines, which began after 1975 with the increased targeting of bigeye tuna (Suzuki et al. 1978), Japanese longliners generally targeted yellowfin tuna using shallow longlines with around five hooks set between the floats (or HPB, hooks per baskets). The proportion of Japanese longline hooks deployed each year within the Indian Ocean with different gear configuration is shown in Figure 11 (based on data reported in Okamoto and Miyabe 1999). After 1975, the proportion of hooks deployed using five HPB decreased rapidly, dropping to less than 10 percent by 1985. Commensurate with this change there was an increase in the proportion of hooks deployed using between 6 and 13 HPB, with sets of 6 or 7 HPB dominating. Between 1987 and the early 1990s the proportion of hooks deployed according to various gear configurations was relatively stable, with around 70 percent of hooks deployed using 6 or 7 HPB and around 20 percent deployed using 11-13 HPB. After this time there is a large change in gear configurations, with a large increase in the proportion of hooks deployed using 8-10 HPB (to around 60 percent) and more than 14 HPB (to around 30 percent). Correspondingly, there is a decrease in the proportion of sets using 6 or 7 HPB (to near zero) and 11-13 HPB (to around 10 percent). The reasons for these changes remain uncertain, but are likely to the due to the introduction of lighter weight monofilament gears.

Despite the changes in gear configurations over time, different gear configurations continued to be used to target different species groups. As a result there are large variations in the gear configurations across the Japanese fleet. This is clearly demonstrated in Figure 12, which indicates the latitudinal changes in gear configurations as the target species shifts from deeper swimming bigeye tunas in the equatorial regions to shallower swimming southern bluefin tunas in the southern regions of the Indian Ocean. Indeed, there is a continuous move to using less HPBs (i.e., setting the line shallower) as one shifts southwards. In the northern Indian Ocean (0-20°N), 18 HPB is the dominate configuration, while farther south the dominate configuration changes from 16-18 HPB in the region 0-20ºS to 10-12 HPB in the region 20-40°S and 8 or 9 HPB in the region south of 40°S.

Korea

Although nominal catch data for Korean longliners operating in the Indian Ocean is available since 1965, spatial catch and effort data is only available since 1975. The time series of reported annual fishing effort is shown in Figure 13. After a large increase in total effort in 1977, reported effort ranged between 58 and 46 million hooks between 1978 and 1983. After this time, effort decreases to around 30 million hooks before increasing again to just over 50 million hooks during the late 1980s. Since that time there have been significant decreases in effort, with the reported effort in 1999 and 2000 being less than 10 million hooks. However, due to the estimated low coverage rates, the actual longline effort may have been appreciably higher in the earlier years, with effort levels being above 100 million hooks prior to 1983.

The mean quarterly spatial distribution of effort for the years 1996, 1997, 1999 and 2000 (when coverage rates averaged 58 percent) is shown in Figure 14, and shows three distinct fishing regions. The main fishing grounds occur in the equatorial regions of the western Indian Ocean, with the areas fished showing some seasonal fluctuations both by latitude and longitude. For example, during the second quarter the majority of fishing effort is in the band 0-10°N, while during the fourth quarter fishing effort is mainly south of the equator in the band 0-15°S. The main target species in this region is bigeye tuna with a significant catch of yellowfin also taken. The other major regions fished are the two areas in the south-eastern and south-western corners of the Indian Ocean between 35-45°S, where southern bluefin tuna is the main target species. Again there is some seasonal shifts in fishing activity with little effort in the first quarter, effort mainly confined to the south-west during the second quarter, then mainly confined to the south-east in the fourth quarter.

Other Fleets

Apart from the data presented above for the three large DWFNs, spatial catch and effort data also exists for several other fleets fishing in the Indian Ocean, though for some of these fleets the amount of data is often quite small, limited to only a few sets or a few years. An indication of the scale of the activities of these “other” fleets (mainly coastal nations) is demonstrated by the data that exist for Australia, China, India, Spain, Reunion, and Seychelles. The time-series of the catch by these six nations since 1990 is shown in Figure 15. Total catches have increased from less than 2,000t in 1990 to around 18,000t in 2000. This nine-fold increase in catch during the 1990s is indicative of the focus by a number of coastal states in developing domestic longline fleets. These developments are likely to continue in the foreseeable future. The spatial distribution of fishing effort for these fleets in recent years is shown in Figure 16. For coastal states, fishing activities are located within or adjacent to their exclusive economic zones and as such display little seasonal variation. For the two non-coastal states, the fishing activities of the Chinese fleet are relatively widespread across the equatorial regions while the Spanish fleet has confined its activities to the region south of the Mozambique Channel.

For many of the coastal states swordfish is the main target species, with bigeye tuna and yellowfin tuna also being caught. For example, during 2001 Australia caught around 2,100t of swordfish, 570t of yellowfin tuna, and 400t of bigeye tuna (Campbell et al. 2002), while Reunion caught 1,740t of swordfish, 500t of albacore, 310t of yellowfin, and 160t of bigeye during 2000 (Poisson and Taquet 2001). These fleets both use modern US-style monofilament longline gears and mainly deploy 6-10 hooks between the floats. Lightsticks are also generally used, especially when targeting swordfish.

Estimate of Total Longline Effort

Despite the information presented above, there still remain large gaps in the data coverage of longline fishing activities in the Indian Ocean. In particular, no effort data exist for the extensive fishing activities of the Indonesian fleet and for the non-reporting NEI fleets mentioned previously. This is despite the combined catch of these fleets estimated to be around 47 percent of the total catch in the Indian Ocean (Table 1).

The number of fresh-tuna longliners operating from Indonesia has been increasing rapidly and continuously since the late 1980s. However, due to incomplete, inaccurate, or a complete lack of data for this fleet estimates for the total catch taken by these vessels has been problematic. A recent reappraisal of the information available to the IOTC indicates that the number of longliners operating in the Indonesian fleet now represents around one-third of all longline vessels operating in the Indian Ocean (Anon 2002b, Herrera 2002a). Up to 1,250 vessels catching in excess of 80,000t have been estimated for recent years. The number of non-reporting fresh tuna longliners operating under flags other than Indonesia is estimated to have reached around 900 vessels in 1993, though there has been a significant decrease in this number to around 300 in recent years due to a re-flagging of many of these vessels to Indonesia (Anon 2002b, Herrera 2002b). Current catches have been estimated at about 25,000t, comprised mostly of yellowfin and bigeye tuna. Finally, the number of non-reporting deep-freezing longline vessels operating in the Indian Ocean is estimated to be around 170, with total catches estimated to be around 60,000t. Honduras, Belize, Equatorial Guinea, and Panama have been the flags most used by this fleet (Herrera 2002b).

The lack of accurate catch data, let alone effort data, makes it difficult to ascertain the current levels of total longline effort in the Indian Ocean. However, an estimate is presented here based on the information that is available. First, estimates of the non-reported effort for the Taiwanese, Japanese, and Korean (TJK) fleets were calculated based on the coverage rates previously described. Second, for each year the catch associated with non-reported effort for non-TJK fleets was estimated by taking the difference between the total catch reported each year for non TJK fleets in the Nominal Catch data and the catch associated with the effort reported for these fleets in the Catch/Effort data. Finally, an estimate of the effort associated with these catches was calculated by assuming that in any year the average catch rate associated with this non-TJK catch was the same as the catch rate estimated for the Taiwanese fleet for that year. For the large NEI fleets this assumption is consistent with the belief that many of these vessels are re-flagged Taiwanese vessels, though how accurate this assumption is across the large Indonesian fleet remains uncertain. The Indonesian fleet is mostly made up of longliners less than 150 GRT and due to the shorter range of the vessels the fishing grounds for the this fleet are limited to the southeast region of the Indian Ocean. The catch rates of coastal states are generally higher than that for DWFNs and their targeting practices are often different, but the catches by these states are relatively small and consequently should not have a large influence on the overall effort estimate.

The estimates of annual longline effort for all fleets operating in the Indian Ocean since 1975 are shown in Figure 17. The estimate of the total effort is seen to have increased from around 300 million hooks in the mid-1970s to around 460 million hooks in 1983 after which time it decreased to around 375 million hooks. After 1987 there was a steady but rapid increase in total effort, peaking at around 870 million hooks in 1993. This increase was mainly due to the increased fishing activities by fleets for which no effort data exist (i.e., non-TJK fleets). After 1993 total effort decreased back below 800 million hooks, but in more recent years is estimated to have generally been around 850 million hooks. As expected, a substantial proportion of the total effort currently remains unreported. Perhaps less expected, however, is the observation that the combined longline effort of the TJK fleets is estimated to have remained relatively stable over the last twenty years, with nearly all the increase in effort over this period due to other fleets. The levels of non-reporting by these other fleets obviously limits our knowledge of the spatial distribution of all longline effort in the Indian Ocean, though some information on the likely location of the effort for the NEI fleets has already been presented. The fishing activities of the Indonesian longline fleet can also be assumed to be mainly limited to the north-eastern region of the Indian Ocean, with the majority of effort likely to be within several hundred miles of the Indonesia coast. On the other hand, for the three main DWFN fleets for which spatial information does exist, the annual distribution of effort in recent years is shown in Figure 18.

Longline - Turtle Interactions

As with other bycatch species, there is no formal reporting of turtles caught by longline vessels operating in the Indian Ocean. There is also a lack of observer coverage on most fleets. As a result, little data, if any, exist on the catch of turtles by most fleets. Nevertheless, some information on the catch of turtles has been reported for the longline fisheries of Reunion and Australia. This information, which is based on logbook reports, is summarised in Table 3 (Poisson and Taquet 2000, Robins et al. 2002). For the Reunion longline fishery, leatherback turtles comprise around half the reported turtle interactions, with hawksbill and green turtles also reportedly caught. Around a quarter of all turtles caught in any year are reported to be dead, though all leatherback are reported as released alive. Catch rates (turtles per million hooks) in this fishery have varied from around 17 in 1997, to 5 in 1998, and 7.7 in 1999. Similar catch rates have been reported by Australian longliners, though the species composition of these catches remains less certain (though most are believed to be leatherback turtles). The coverage of all turtle interactions by these logbook reports remains unknown, but true interactions rates may be substantially higher. For example, based on interviews with vessel skippers, Robins et al. (2002) estimated that catch rates for Australian longliners are around 24 turtles per million hooks. Some observer data are also available for the Japanese longline fleet operating in the southern parts of the Indian Ocean, principally south of 35°S. Collected as part the Real Time Monitoring Program covering the fishery for southern bluefin tuna, around 6 million hooks were monitored between March 1992 and January 1996. No turtles were reported caught.

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Questions and Discussion

Question: What is “NEI”?

Response: “NEI” stands for Not Elsewhere Included. These are flagged vessels that do not report to the Indian Ocean Tuna Commission (IOTC). NEI is roughly equivalent to the term “IUU”, which is used by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Both are important when considering global bycatch issues, in terms of how to capture or record this effort.

Table 1. List of fishing fleets (nations or fishing entities) with reported or estimated longline catch between 1996 and 2000. The total reported catch taken by each fleet during this period is also shown. Note the fleets are listed in decreasing order by catch and these catches are shown apportioned to the eastern and western Indian Ocean. The catch by each fleet, as a proportion of the total catch across all fleets, is also shown.

Fleet	Western	Eastern	Total	Percent
Taiwan	382,358	120,667	503,025	31.54%
Indonesia	0	354,522	354,522	22.23%
NEI-Deep Freezing	183,804	58,556	242,360	15.19%
Japan	130,576	70,513	201,089	12.61%
NEI-Fresh Tuna	1,376	137,815	139,191	8.73%
Korea	51,264	1,784	53,048	3.33%
China	1,883	18,327	20,210	1.27%
NEI-Indonesia Fresh	0	16,078	16,078	1.01%
Spain	15,352	0	15,352	0.96%
France-Reunion	13,444	0	13,444	0.84%
Philippines	327	8,155	8,483	0.53%
Australia	0	7,073	7,073	0.44%
Pakistan	4,405	0	4,405	0.28%
Sri Lanka	0	4,067	4,067	0.26%
South Africa	3,000	0	3,000	0.19%
Portugal	2,343	0	2,343	0.15%
Seychelles	2,081	0	2,081	0.13%
India	686	1,005	1,690	0.11%
France-Territories	1,592	0	1,592	0.10%
Iran	743	0	743	0.05%
Maldives	621	0	621	0.04%
Thailand	0	385	385	0.02%
Mauritius	166	0	166	0.01%
Saudi Arabia	61	0	61	0.00%
Total	796,082	798,948	1,595,029	100%

Table 2. Breakdown of total catch between 1996-2000 by main species groups. Light shading indicates those species group comprising greater than 20 percent of the total catch, while dark shading indicates those species groups comprising between 10 and 20 percent of the total catch.

FLEET	Yellowfin Tuna	Bigeye Tuna	Albacore Yuna	Southern Bluefin	Broadbill Swordfish	Other Billfish	Others Species	Total Catch (tonnes)
Taiwan	20.8%	35.2%	19.5%	1.0%	16.2%	6.0%	1.3%	503,025
Indonesia	47.8%	35.5%	3.3%	4.3%	1.6%	4.9%	2.6%	354,522
NEI-DFRZ	20.7%	35.1%	19.6%	1.4%	16.0%	5.9%	1.2%	242,360
Japan	35.4%	37.6%	6.6%	11.7%	4.9%	3.7%	0.0%	201,089
NEI-Ice	68.4%	18.8%	0.3%	0.0%	3.8%	6.9%	1.8%	139,191
Korea	21.3%	51.5%	0.7%	10.8%	0.9%	7.6%	7.2%	53,048
China	31.4%	45.3%	0.9%	0.0%	6.2%	3.8%	12.3%	20,210
NEI-Ind Ice	49.6%	36.2%	2.0%	3.7%	1.5%	4.7%	2.2%	16,078
Spain	1.2%	1.0%	1.1%	0.0%	32.3%	0.3%	64.1%	15,352
France-Reunion	10.1%	4.9%	12.0%	0.0%	64.4%	3.6%	5.0%	13,444
Philippines	18.2%	55.8%	9.3%	0.0%	9.4%	5.5%	1.8%	8,483
Australia	21.8%	17.1%	1.5%	4.6%	50.3%	1.5%	3.1%	7,073
Pakistan	70.7%	0.0%	0.0%	0.0%	0.0%	29.3%	0.0%	4,405
Sri Lanka	36.5%	34.1%	0.0%	0.0%	7.5%	7.2%	14.7%	4,067
South Africa	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	3,000
Portugal	1.1%	0.0%	0.0%	0.0%	23.1%	0.0%	75.8%	2,343
Seychelles	14.9%	14.4%	0.0%	0.0%	54.6%	3.6%	12.5%	2,081
India	34.6%	0.2%	0.0%	0.0%	9.5%	13.4%	42.4%	1,690
France-Territories	12.2%	7.7%	12.5%	0.0%	58.7%	3.2%	5.6%	1,592
Iran	83.7%	9.4%	0.0%	0.0%	4.6%	2.1%	0.1%	743
Maldives	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	95.7%	621
Thailand	59.1%	28.5%	3.2%	0.0%	5.0%	4.1%	0.0%	385
Mauritius	26.1%	10.3%	0.0%	0.0%	0.0%	18.1%	45.5%	166
Saudi Arabia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	61
Total	33.1%	33.9%	10.9%	3.4%	10.5%	5.5%	2.7%	1,595,029

Table 3. Logbook reports of turtles caught in by Reunion and Australian longline fleets operating in the Indian Ocean.

Year	Leatherback		Green		Hawksbill		Unidentified		Total		Hooks	Rate
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead	(1000s)	(per million hks)
Reunion												
1997	21	0	2	0	13	12	4	0	40	12	3,000	17.33
1998	8	0	2	1	3	0	3	3	16	4	4,000	5.00
1999	11	0	4	4	7	2	2	2	24	8	4,150	7.71
Australia												
1999									24		3,529	6.80
2000									34		6,220	5.47
2001									27		6,183	4.37

Figure 1. Time-series of total reported catch of tuna and tuna-like species by year and fishing method in the Indian Ocean since 1952.

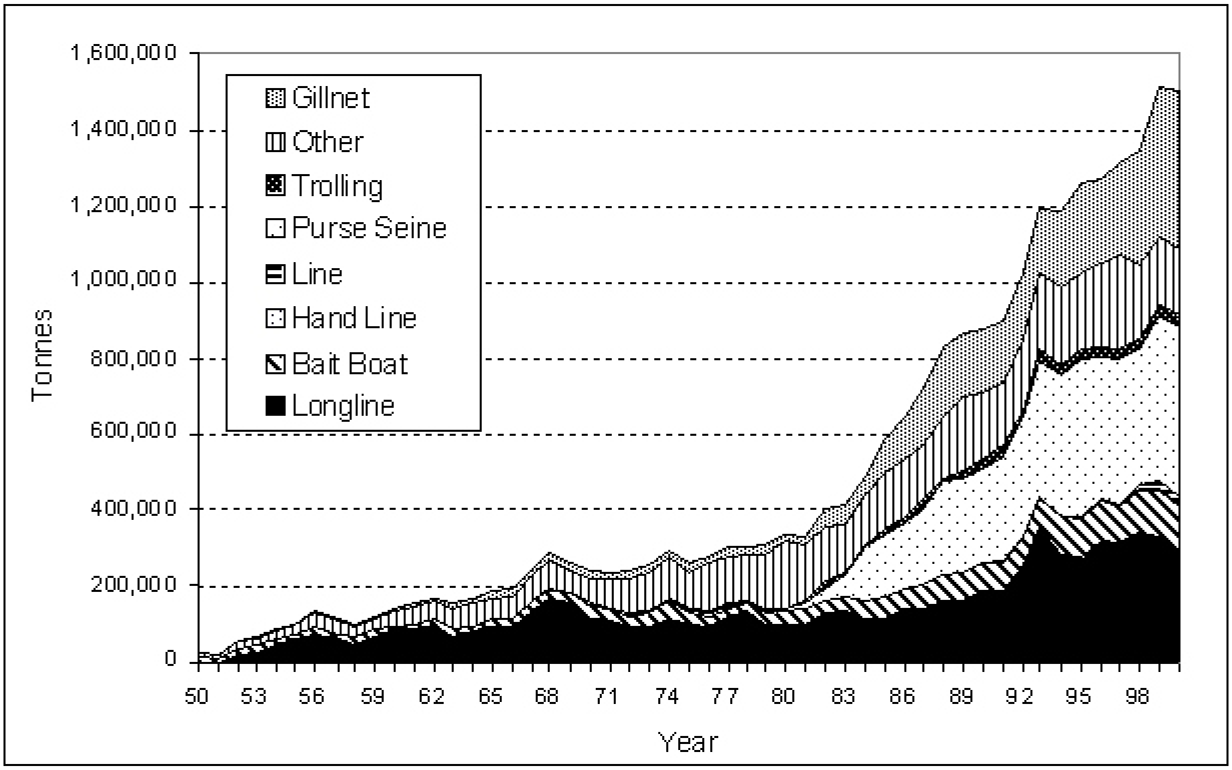
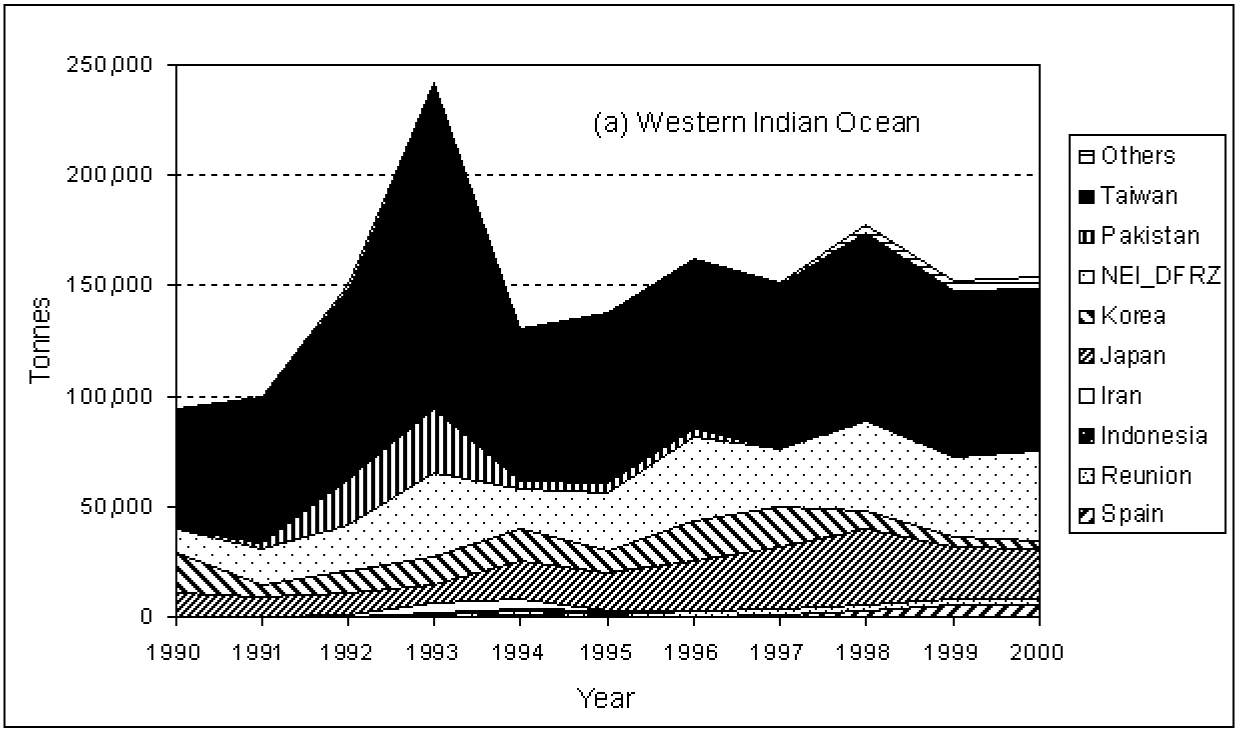


Figure 2. Time-series of total reported catch of tuna and tuna-like species in (a) the western Indian Ocean, and (b) the eastern Indian Ocean by year and principal catch nation.



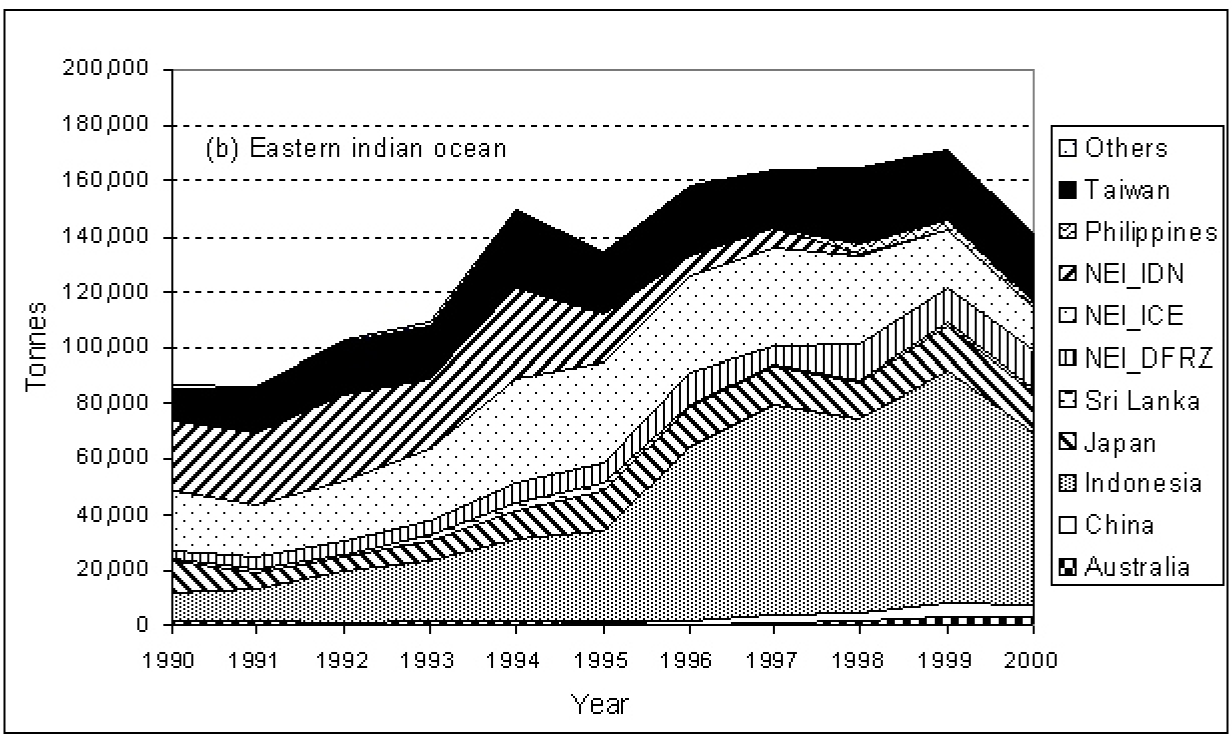


Figure 3. Time-series of annual estimates of coverage in Catch/Effort data for the Taiwanese, Japanese and Korean fleets.

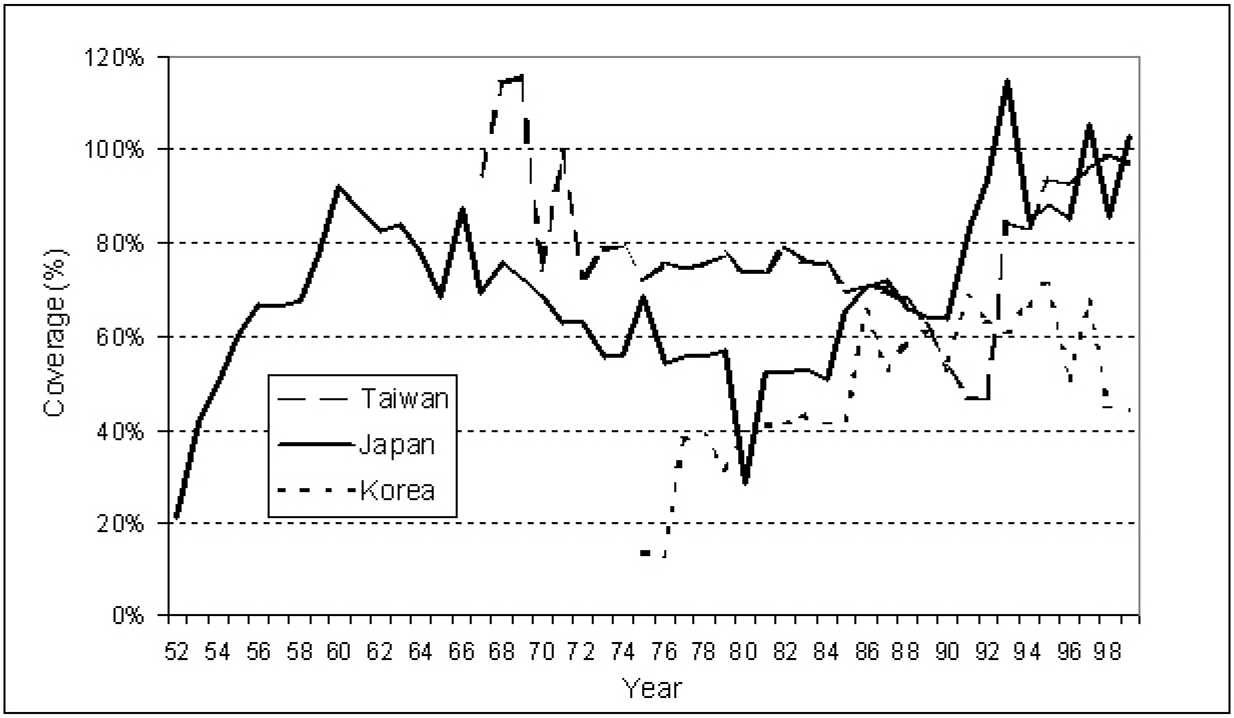


Figure 4. Time-series of annual fishing effort (number of hooks) reported by Taiwanese longline vessels fishing in the Indian Ocean. The effort within each quarter of the year is also shown, as is an estimate of the amount of non-reported effort for each year with the question mark denoting that this quantity is an estimate. Note: the data for 1999 may be incomplete and would account for the relative increase in the proportion of effort in the first quarter.

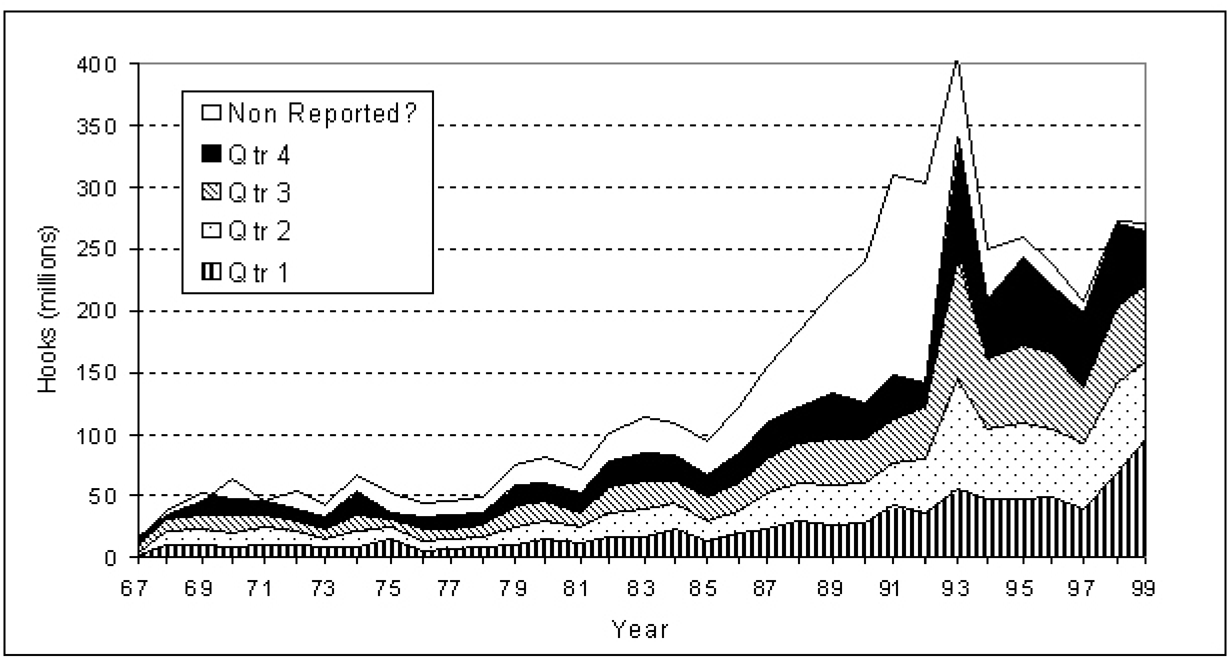


Figure 5. Mean annual spatial distribution of the catch reported by Taiwanese longline vessels operating in the Indian Ocean between 1994 and 1998, with the proportion by species of the total catch caught in each 5x5-degree region also indicated.

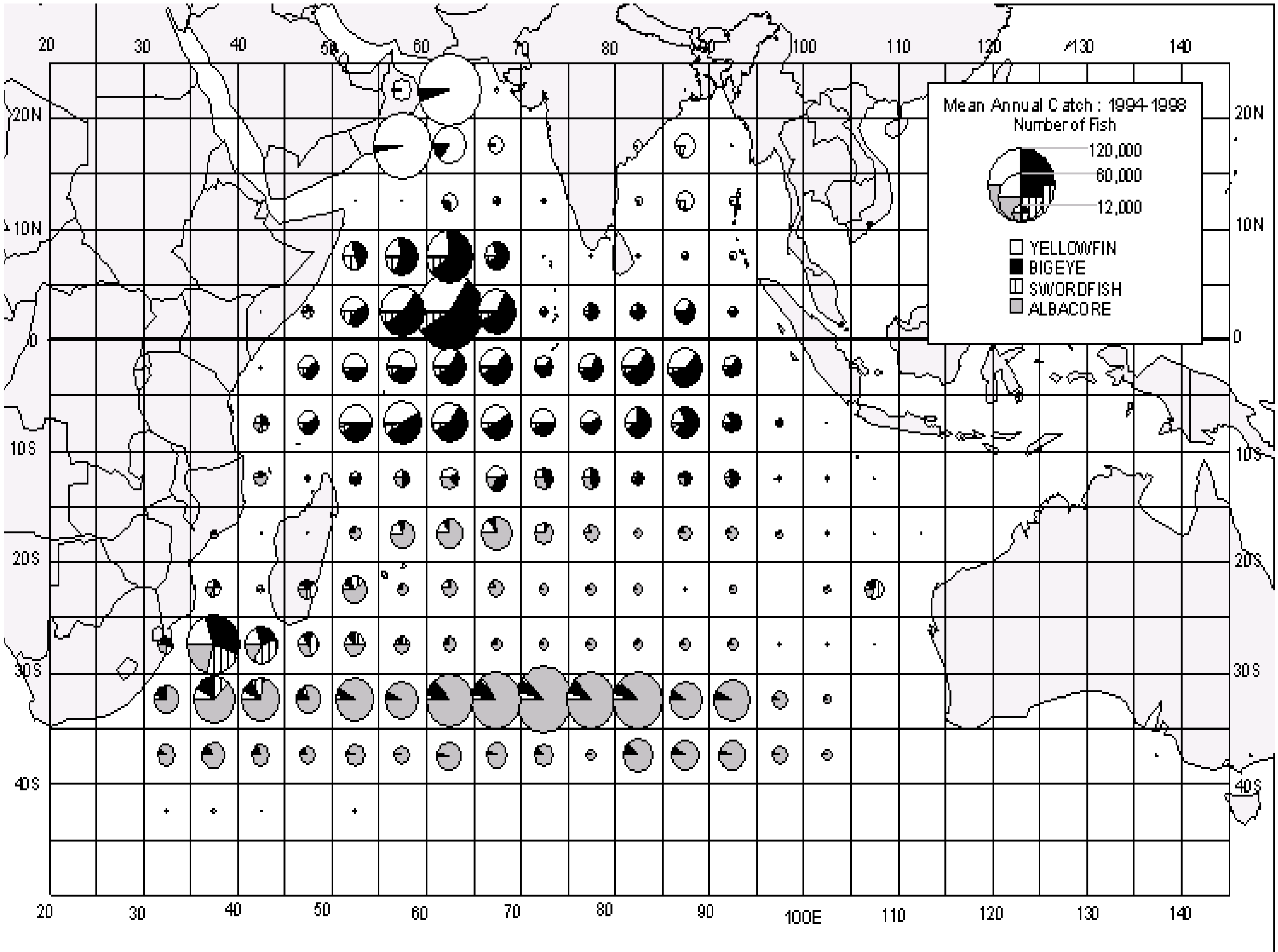


Figure 6. Mean spatial distribution of the effort reported by Taiwanese longline vessels operating in the Indian Ocean between 1994 and 1998, by quarter of the year.

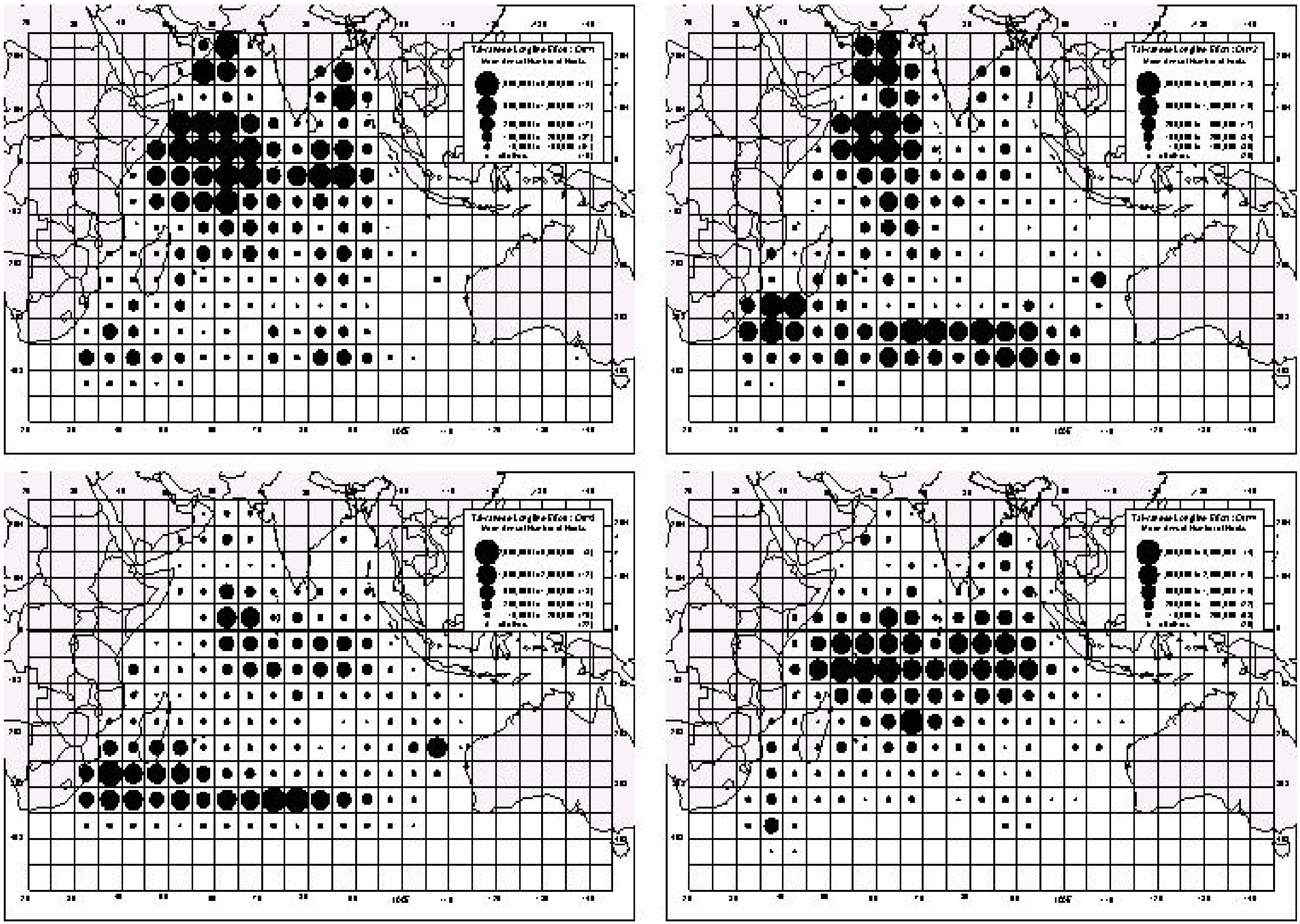


Figure 7. Time-series of annual fishing effort (number of hooks) reported by Japanese longline vessels fishing in the Indian Ocean. The effort within each quarter of the year is also shown, as is an estimate of the amount of non-reported effort for each year with the question mark denoting that this quantity is an estimate.

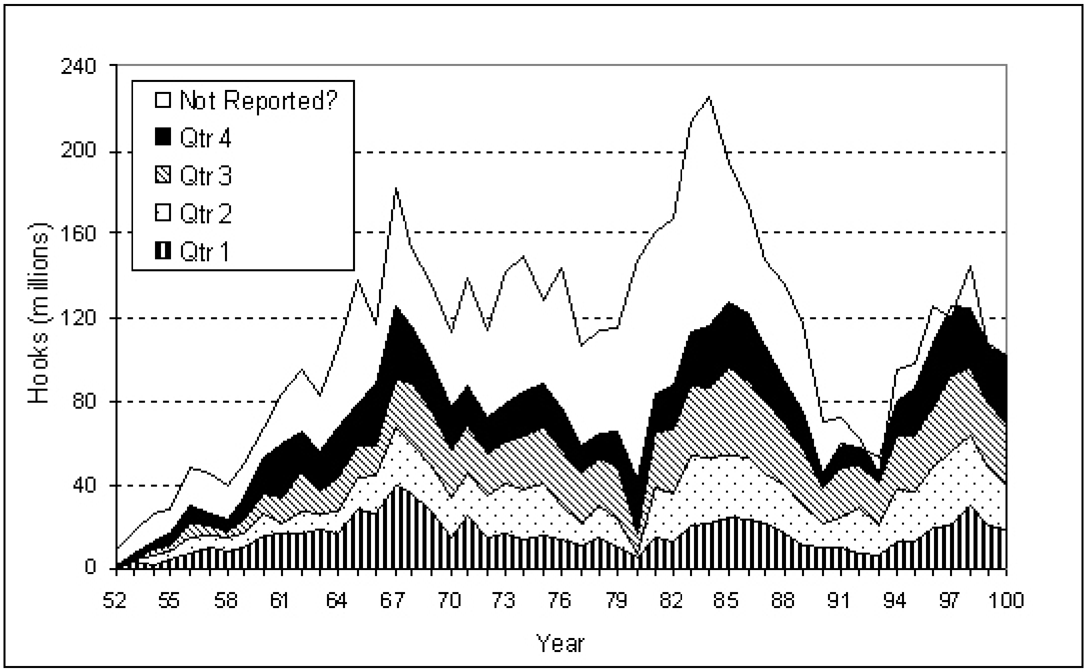


Figure 8. Time-series of the proportion of the annual fishing effort reported by Japanese longline vessels fishing within each 10-degree latitudinal band across the Indian Ocean.

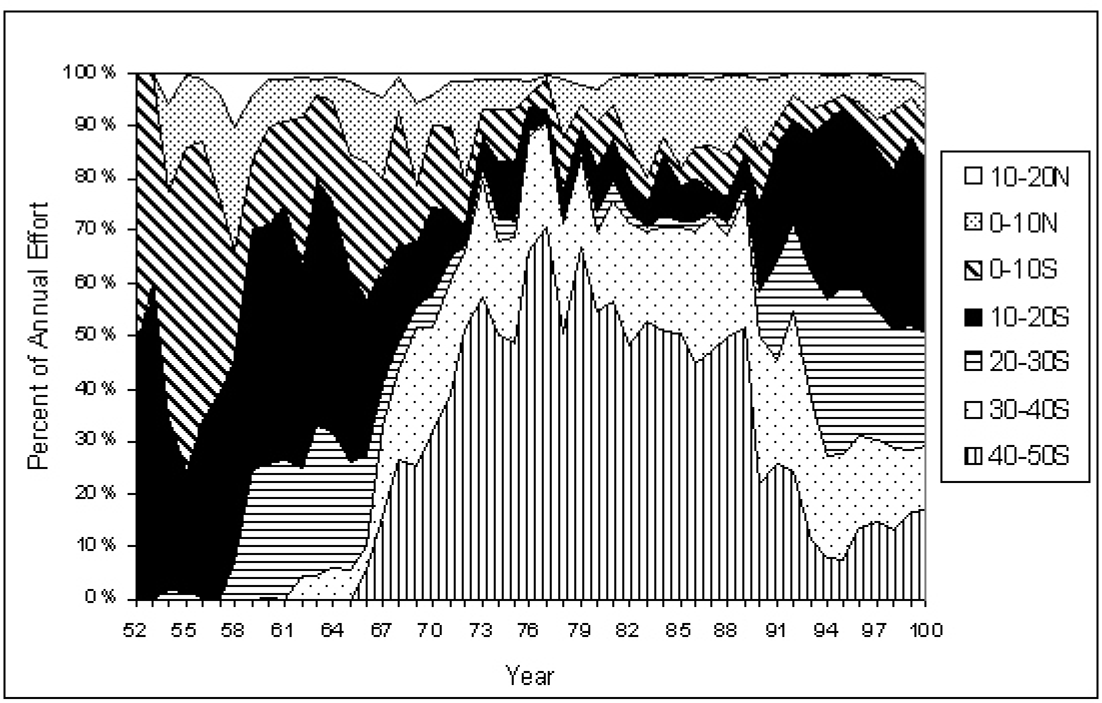


Figure 9. Mean annual spatial distribution of the catch reported by Japanese longline vessels operating in the Indian Ocean between 1996 and 2000, with the proportion by species of the total catch caught in each 5x5-degree region also indicated.

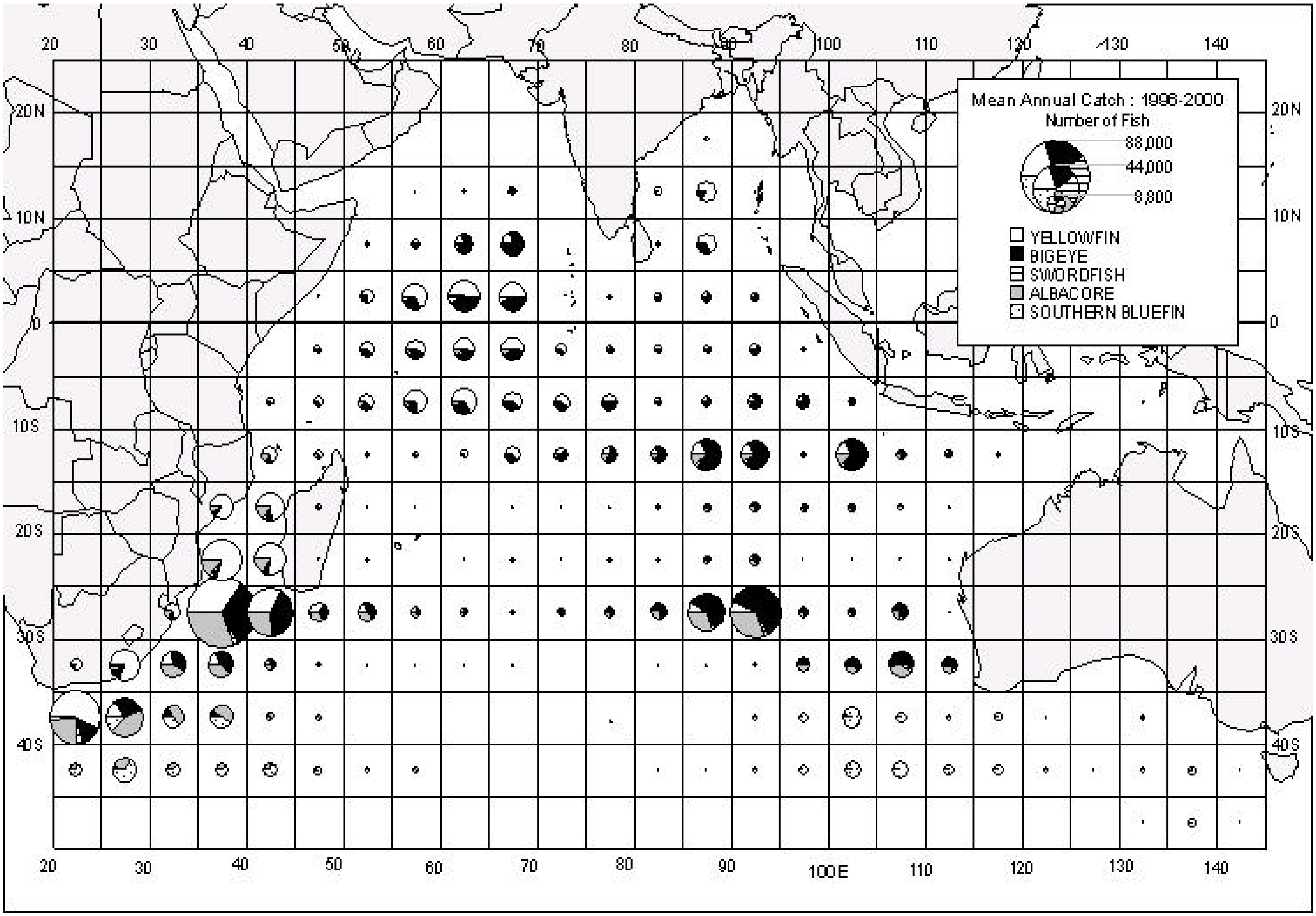


Figure 10. Mean spatial distribution of the effort reported by Japanese longline vessels operating in the Indian Ocean between 1996 and 2000, by quarter of the year.

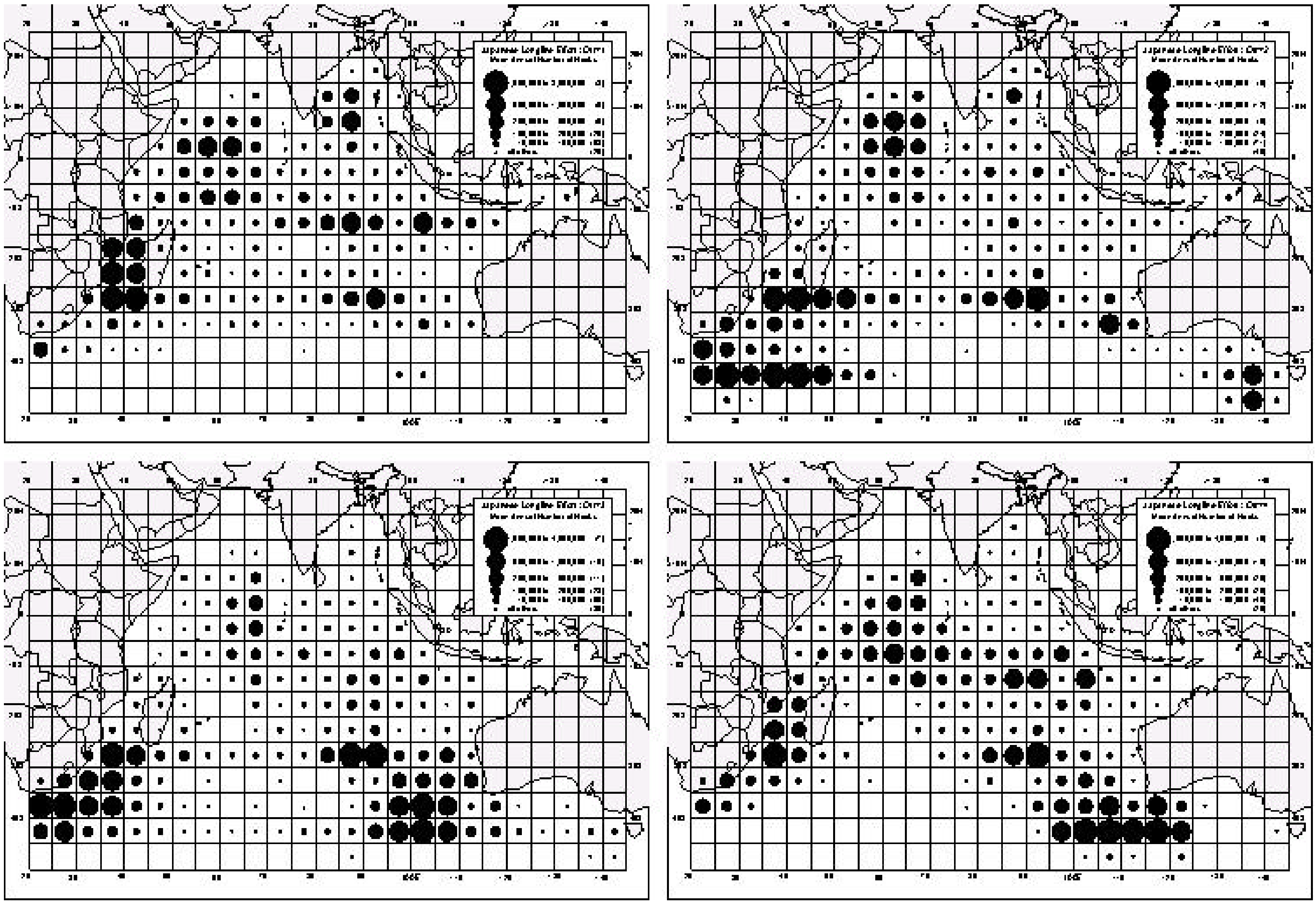


Figure 11. Time series of the proportion of total Japanese longline effort deployed in the Indian Ocean using different gear configurations (i.e., number of hooks between floats).

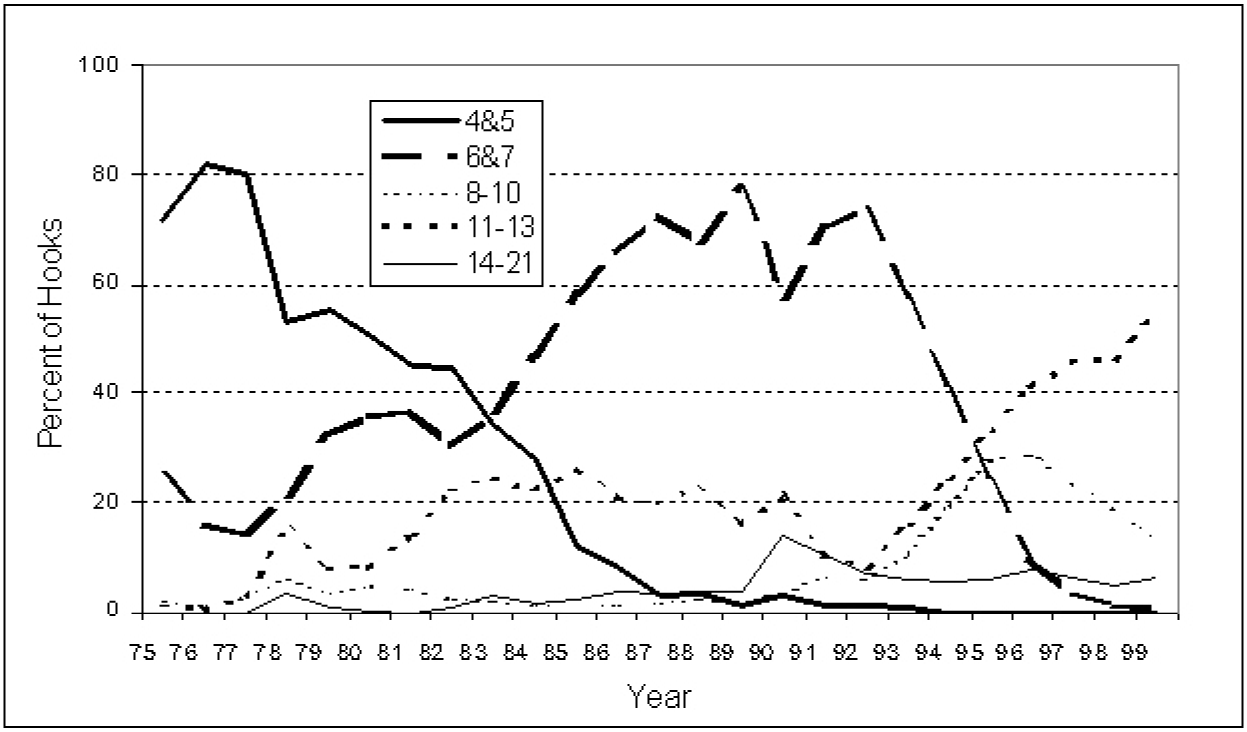


Figure 12. Mean proportion (across the years 1997-99) of Japanese longline effort within each 20-degree latitudinal band across the Indian Ocean deployed using different gear configurations.

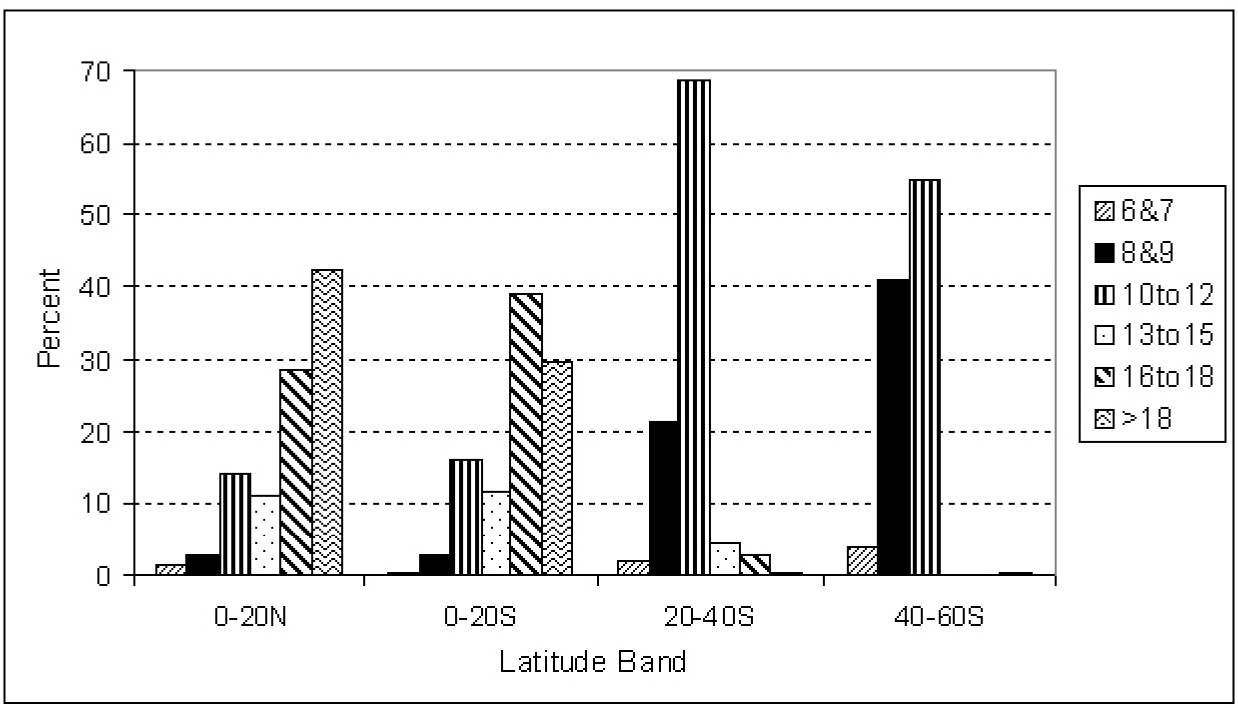


Figure 13. Time-series of annual fishing effort (number of hooks) reported by Korean longline vessels fishing in the Indian Ocean. The effort within each quarter of the year is also shown, as is an estimate of the amount of non-reported effort for each year with the question mark denoting that this quantity is an estimate.

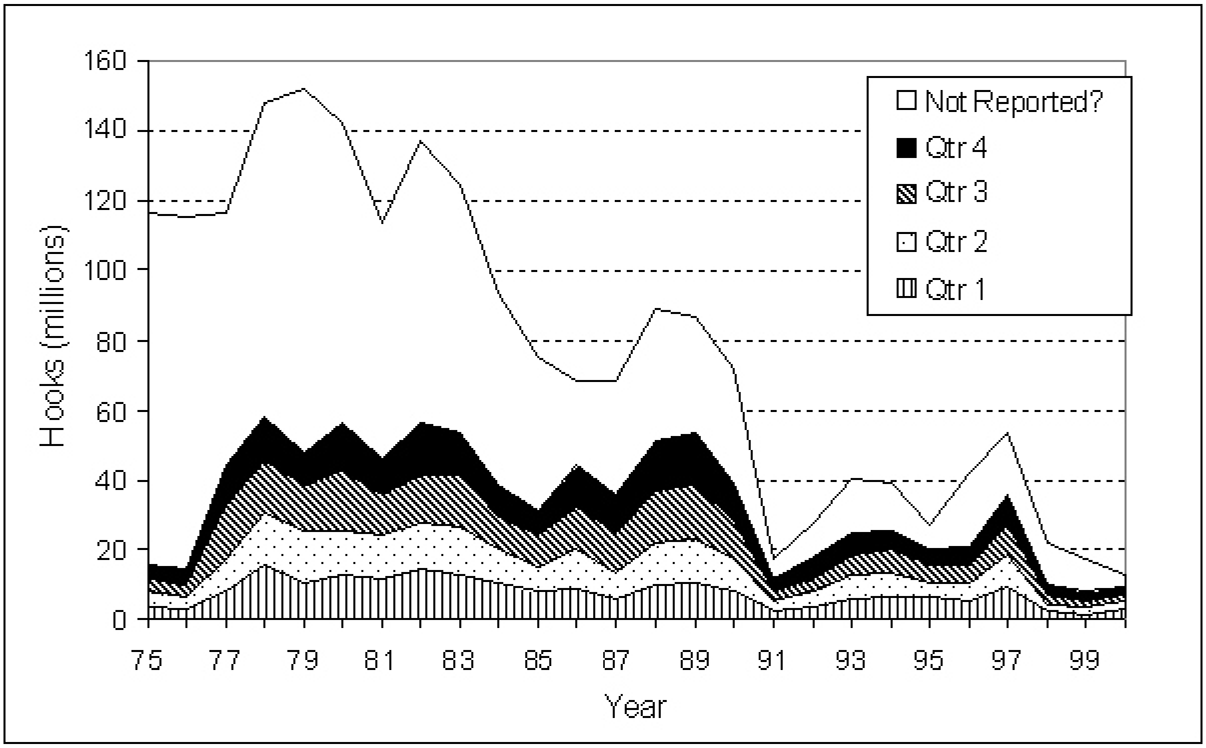


Figure 14. Mean spatial distribution of the effort reported by Korean longline vessels operating in the Indian Ocean between 1996 and 2000, by quarter of the year.

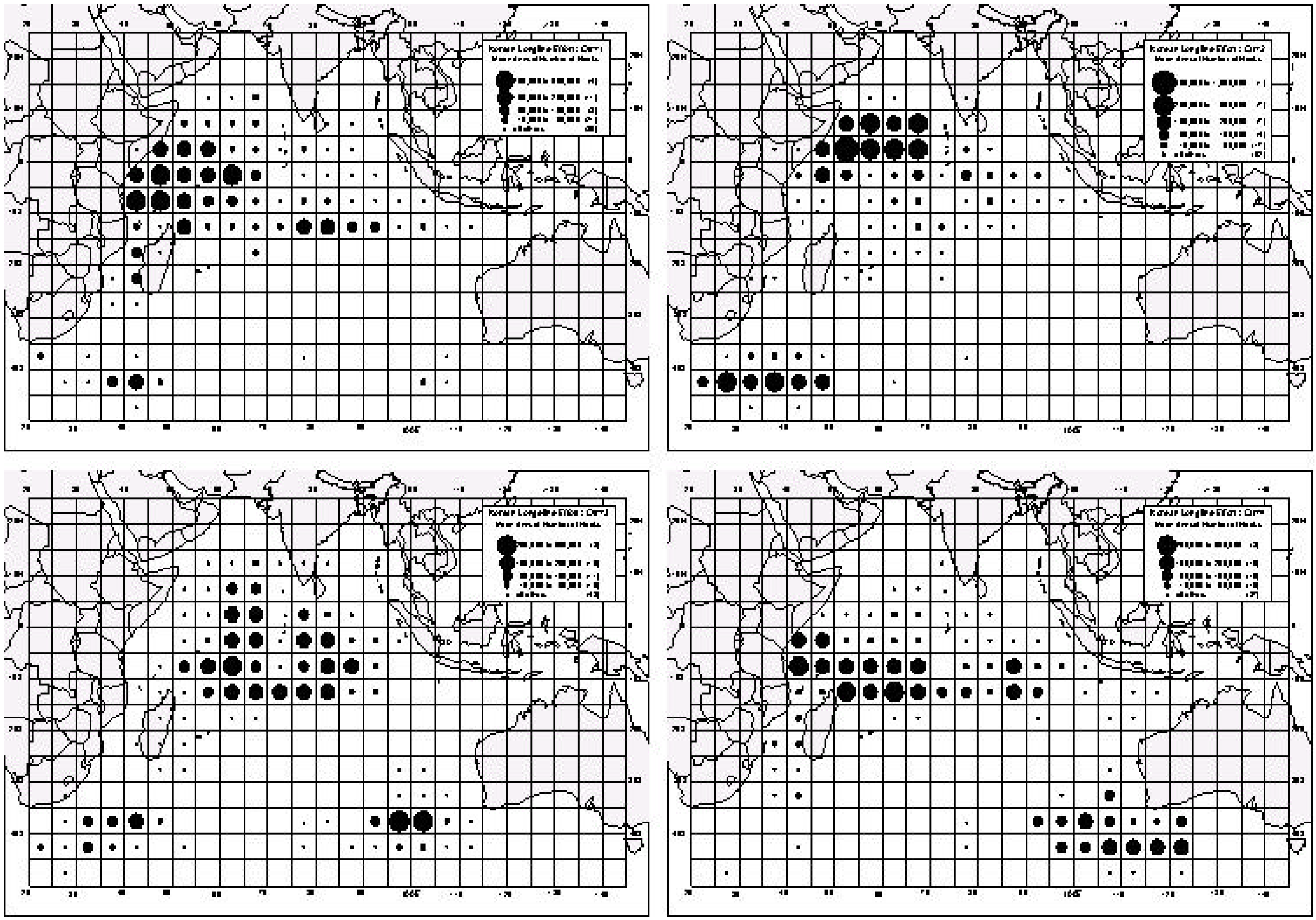


Figure 15. Time-series of total reported catch of tuna and tuna-like species by various longline fleets operating in the Indian Ocean.

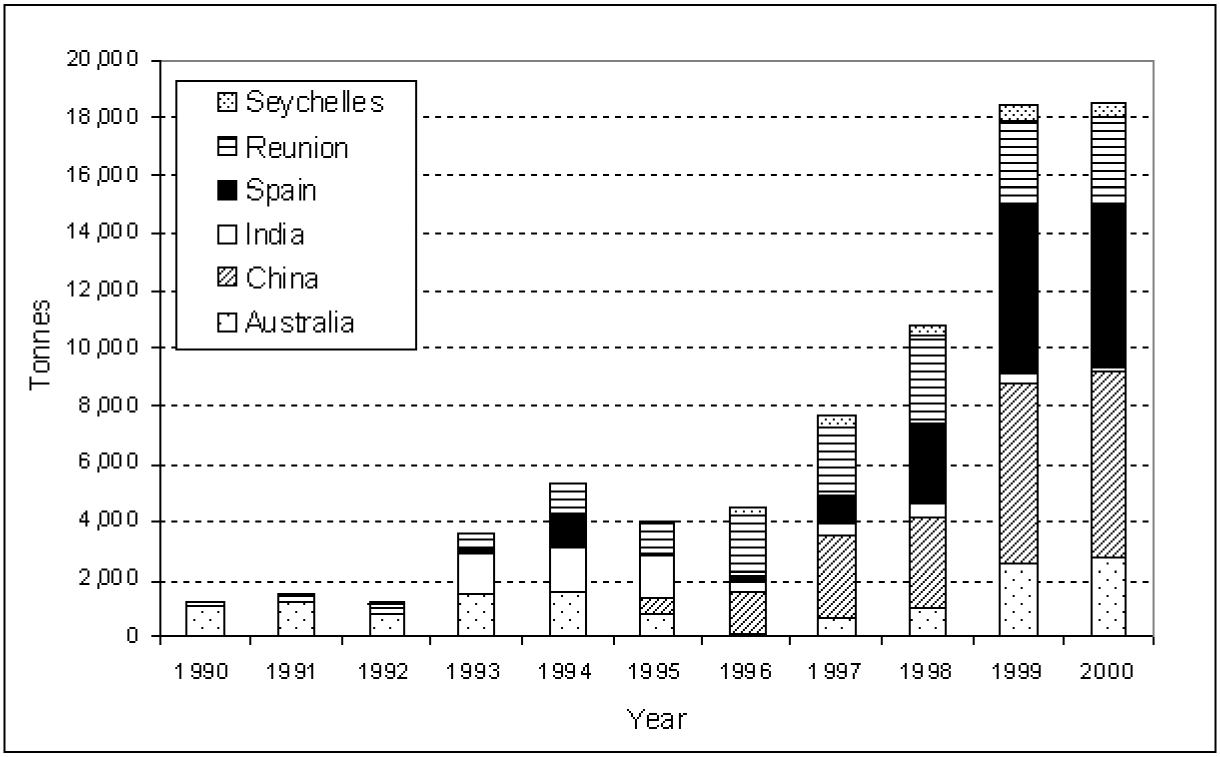


Figure 16. Spatial distribution of the fishing effort reported by various longline fleets operating in the Indian Ocean for indicative years between 1997 and 2000. The unshaded circles north and south of Madagascar indicate the Seychelles and Spanish fleets respectively, while the lightly shaded dots refer to the Chinese fleet. The dark dots in the eastern, western and northern Indian Ocean refer to the Australian, Reunion, and Indian fleets respectively. Note: some dots overlap.

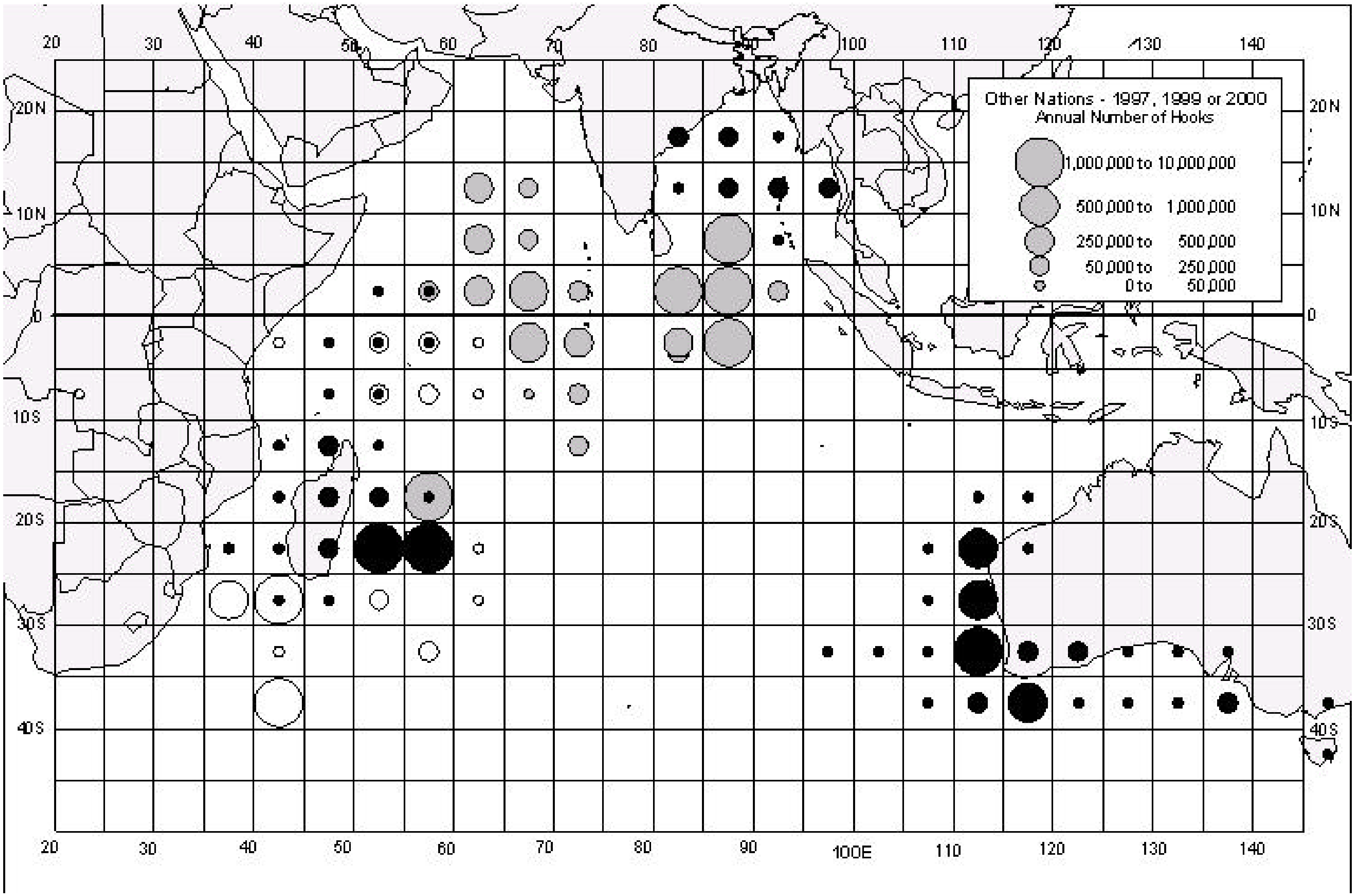


Figure 17. Time-series of reported and estimated non-reported longline fishing effort in the Indian Ocean by year and principal catch fleets. Separate estimates of non-reported effort have been made for the Taiwanese, Japanese, and Korean (TJK) fleets combined and for all other fleets combined with the question mark denoting that these quantities are estimates.

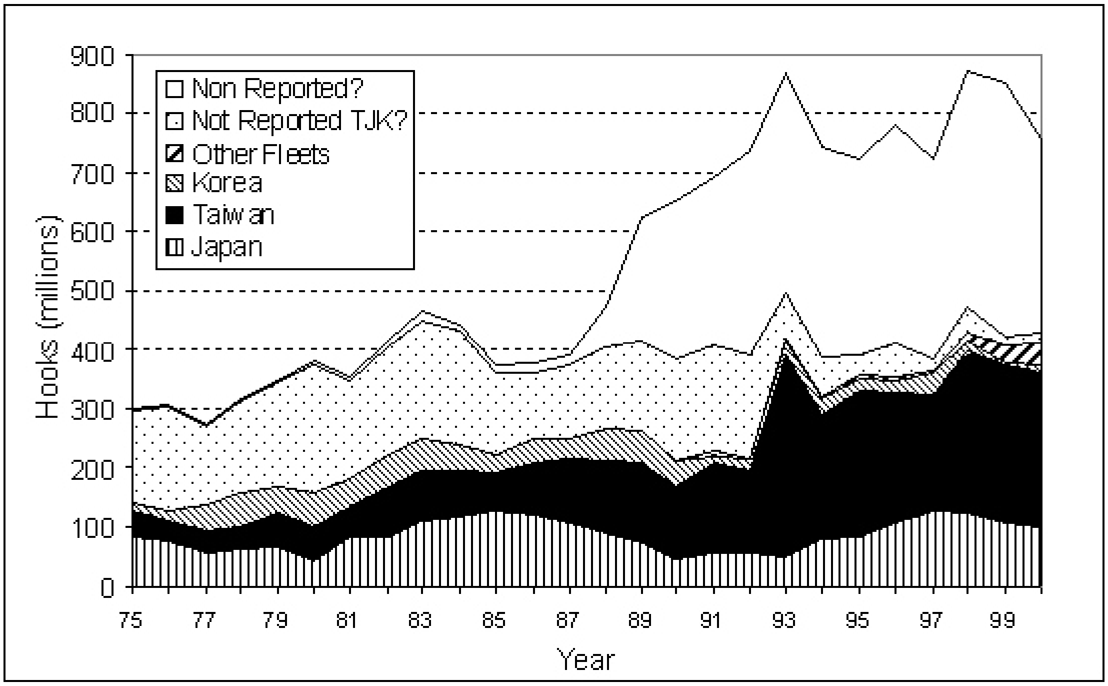
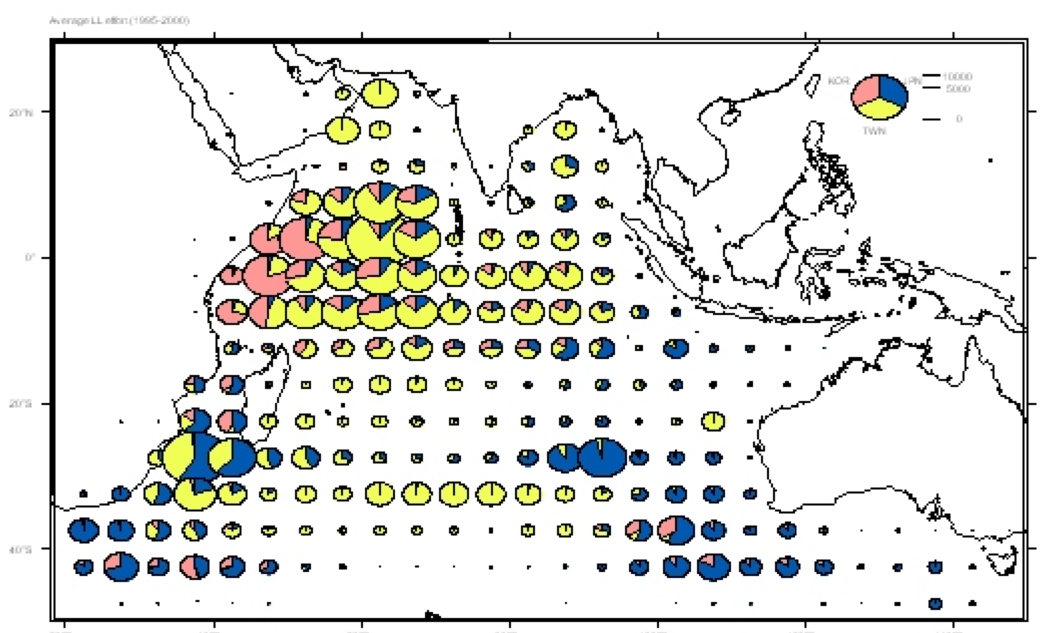


Figure 18. Mean spatial distribution of annual fishing effort for the Taiwanese, Japanese, and Korean longline fleets operating in the Indian Ocean between 1995 and 2000 (courtesy IOTC).



GLOBAL AND SEASONAL DISTRIBUTION AND EFFORT, GEAR CONFIGURATION, TARGET SPECIES, AND EFFORT TRENDS IN THE ATLANTIC OCEAN

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Background – ICCAT

The Regional Fishery Management Organization (RFMO) which deals with tuna and tuna-like fisheries in the Atlantic Ocean and adjacent seas is the International Commission for the Conservation of Atlantic Tunas (ICCAT, also see www.iccat.es), which is headquartered in Madrid, Spain. The organization was established in 1969, based on the International Convention for the Conservation of Atlantic Tunas, which was signed in Rio de Janeiro, Brazil, in 1966. About 30 species of tuna and tuna-like fishes are of direct concern to ICCAT, including bluefin (BFT), yellowfin (YFT), albacore (ALB), bigeye (BET), and skipjack (SKJ) tunas as well as swordfish (SWO), white marlin (WHM), blue marlin (BUM), sailfish (SAI), and spearfish (SPF), among others. Many Parties use longline fishing methods to catch these species.

ICCAT is the responsible RFMO tasked to undertake the range of work required for the study and management of fisheries harvesting tunas and tuna-like species in the Convention area. As such, ICCAT compiles fishery statistics from its members and from all entities fishing for these species in the Atlantic Ocean; coordinates research, including stock assessments, on behalf of its members; develops scientific-based management advice regarding conservation or rebuilding of stocks of concern; provides a mechanism for contracting parties to agree on management measures; and produces relevant publications.

Studies undertaken by ICCAT include research on biometry, ecology, and oceanography, with a principal focus on the effects of fishing on stock abundance. The Commission's work requires the collection and analysis of statistical information relative to current conditions and trends of the fishery resources in the Convention area. The Commission also undertakes work in the compilation of data for other fish species that are caught during tuna fishing ("bycatch", principally sharks) in the Convention area, and which are not investigated by another international fishery organization.

The Convention is open for signature, or may be adhered to, by any Government which is a Member of the United Nations or of any specialized agency of the UN. Instruments of ratification, approval, or adherence may be deposited with the Director-General of the UN's Food and Agriculture Organization, and membership is effective on the date of such deposit. In early 2002, there were 34 contracting parties: Algéri; Angola; Barbados; Brasil; Canada; Cap-Vert; People's Republic of China; Communauté Europénne; Côte D'Ivoire; Croatia; France (St-Pierre et Miquelon); Gabon; Ghana; Guinea Ecuatorial; Guinée-Conakry; Honduras; Iceland; Japan; Republic of Korea; Libya; Maroc; Mexico; Namibie; Panama; Russia; São Tomé E Principe; South Africa; Trinidad & Tobago; Tunisie; United Kingdom (Bermuda); Uruguay; Vanuatu; Venezuela; and the United States.

The Commission can, on the basis of scientific evidence and other relevant information, recommend management measures and Resolutions aimed at carrying out its objective of maintaining the populations of tuna and tuna-like fishes at "levels which will permit maximum sustainable catch". Scientific advice is prepared by the Standing Committee on Research and Statistics (SCRS), the organization´s scientific branch. The number of Resolutions and Recommendations that the Commission adopts each year has been increasing (Figure 1). Much of the work of the Commission over the past several years has been directed at combating the influx of IUU fishing in the Atlantic, an activity that has and continues to undermine the management actions agreed by the Commission. In 2002, 380 large-scale (>24m LOA) longline vessels were believed to be engaged in Illegal, Unregulated, and Unreported Fishing Activities in the ICCAT Convention Area (and other areas).

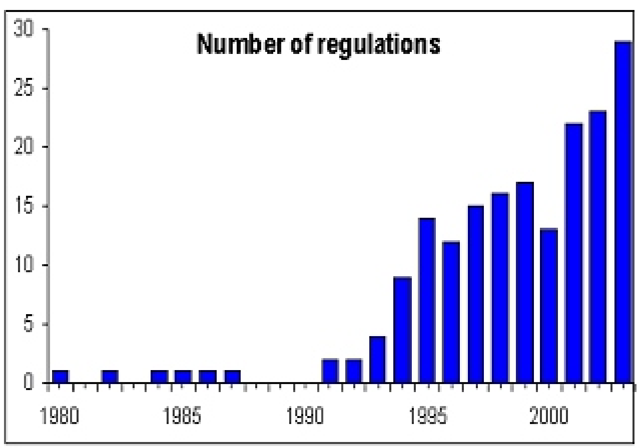


Figure 1. The number of regulations adopted annually by ICCAT through consensus among contracting parties.

ICCAT strives to obtain complete and accurate statistics from all countries, entities and fishing entities operating tuna and tuna-like fisheries in the Atlantic and Mediterranean. All countries/entities or fishing entities which operate tuna and/or shark fisheries in the Atlantic Ocean and adjacent seas are requested to submit their tuna/shark fisheries data. The type of data collected by ICCAT include: (1) Task I catch statistics - Nominal annual catch of tuna and tuna like fish, by region, gear, flag and species, and, where possible, by EEZ and High Seas; (2) Task I fishing power (fleet) statistics - Number of fishing vessels by size classes, gear and flag, and, where possible, by

EEZ and High Seas; (3) Task II catch and effort statistics - Catch and effort statistics by area, gear, flag, species and by month; (4) Task II size data - Actual size frequencies of fish sampled by area, gear, flag, species and by month; (5) Catch-at-size data - Catch-at-size data for bluefin, albacore, yellowfin, bigeye and skipjack tunas and swordfish, by gear, sampling area and by month or quarters, and for swordfish by sex and by 5x5 degree rectangles if possible; (6) Shark data - Catch by quarter and 5x5 area, gear, species and year; and (7) Observer data - a number of nations have observer programs in place and the information collected from such programs has been or could be provided to ICCAT. The SCRS has recommended that Contracting Parties, and Cooperating non-Contracting Parties, Entities or Fishing Entities that can do so, should provide their observer data to the Secretariat.

Who, What, and How Much Catch & Effort

While there are a multitude of gear types used to capture Atlantic tuna and tuna-like species from the Convention area, longline fishing ranks second behind purse-seine in the volume of catch made annually. Detailed records of catch and effort beginning in the 1950's, which corresponds to the advent of distant water longline fishing in the Atlantic by the Japanese, are held by ICCAT. Recent levels of longline catch from the Atlantic have been on the order of 160,000 mT per year (Figure 2).

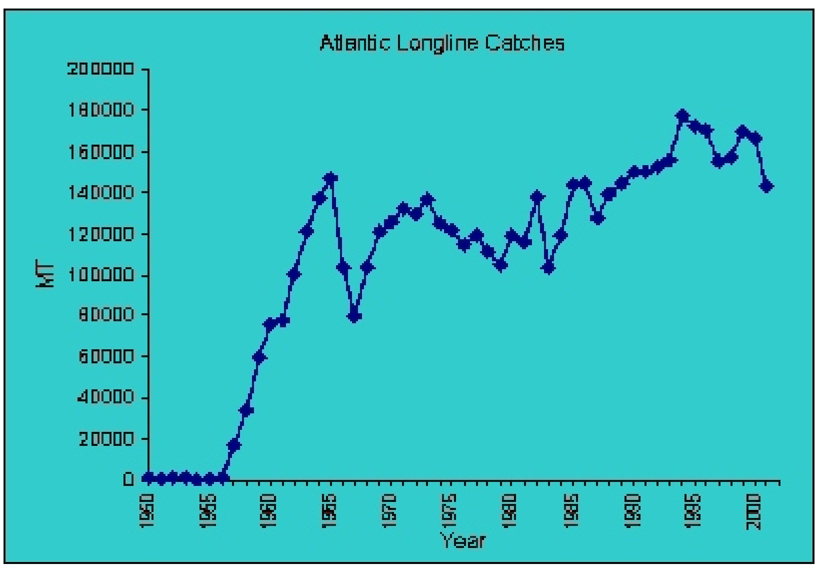


Figure 2. The evolution of Atlantic longline catch by year since the 1950s.

In terms of species composition of the catch, the dominant species have varied over time (Figure 3). While swordfish has always been an important component of the longline catch, the contribution of yellowfin tuna, albacore and bigeye tuna to the total has changed over time. Bluefin tuna has been a consistently small proportion of the total, as has been the catch of marlins and of other tuna species. In general, these patterns reflect both the relative abundance or availability of the species indicated to the gear, as well as the tendency of the fisheries to target different species over time.

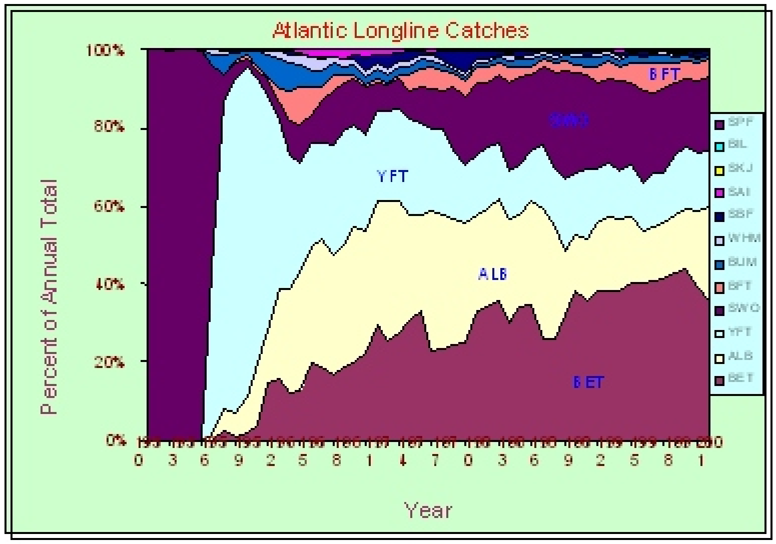


Figure 3. Proportional contribution of different species to the total annual longline catch of Atlantic tunas and tuna-like species.

Among other means, such as controlling the depth of fishing, targeting of different species is reflected in the spatial distribution of the gear. Much of this is reflected in the distribution of longline fishing effort (in hooks fished) by latitude bands. Figure 4 indicates the evolution of nominal hooks fished in Northern, Southern, and Tropical waters over time. Recent effort is distributed more within the tropical region than at the onset of the fishery.

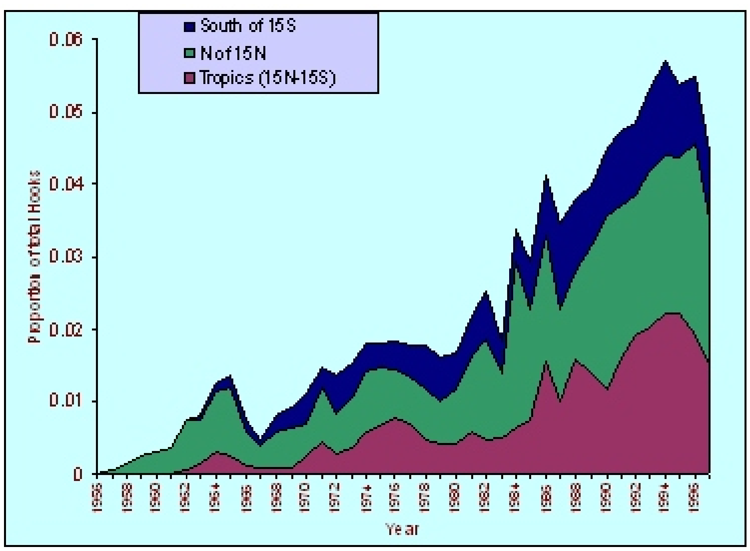
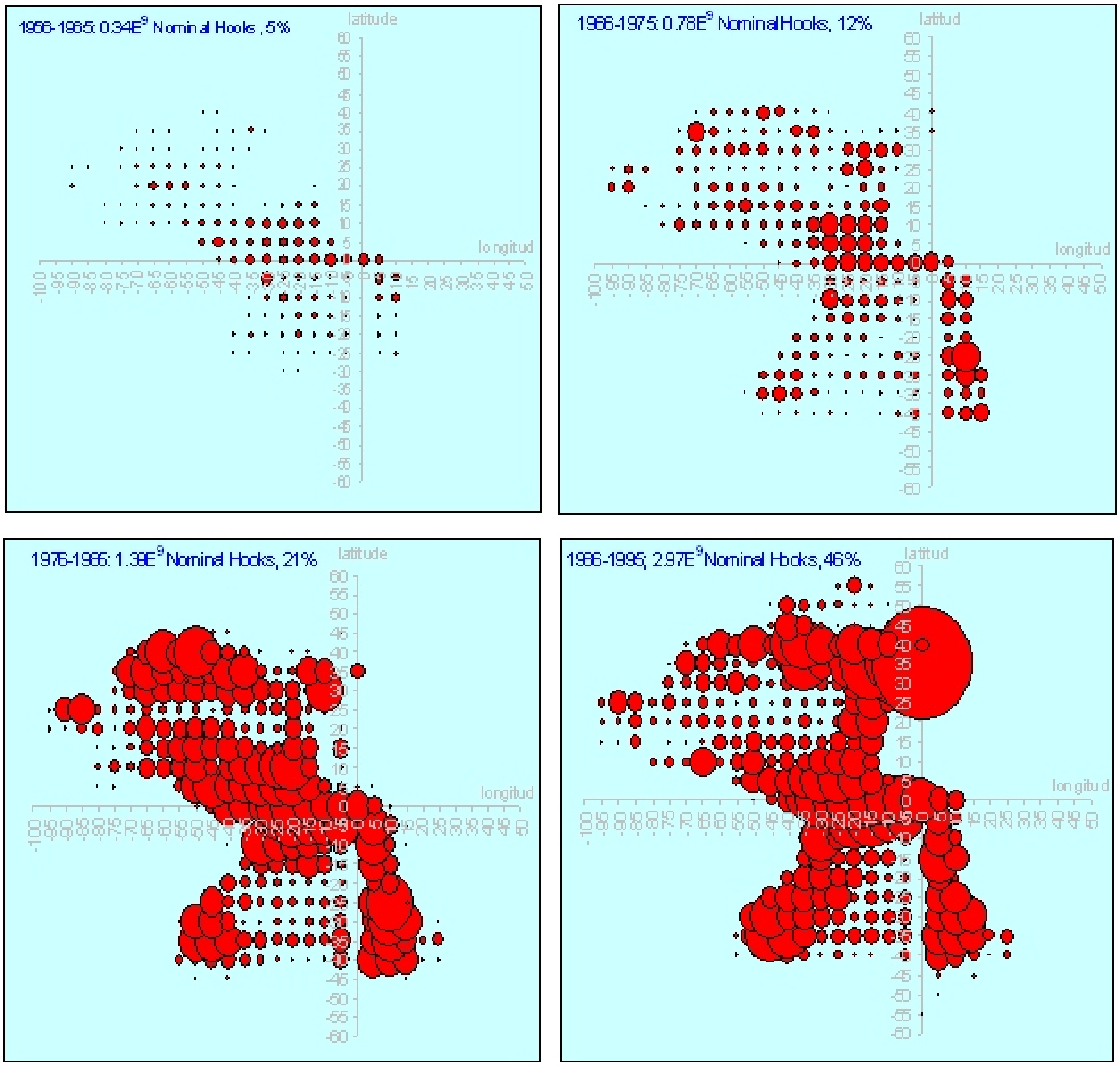


Figure 4. Distribution of nominal hooks reported fished by year within the Northern, Southern and Tropical zones.

Perhaps a better view of the evolution of longline fishing effort in the Atlantic is through an examination of 5x5 data by decade (Figure 5). During the initial decade of recorded longline fishing, there were on average 34,000,000 hooks fished per year from 1956-1965. The level of effort approximately doubled in each of the subsequent decades to an annual average of 78,000,000 hooks fished per year from 1966-1975; 139,000,000 hooks fished per year from 1976-1985; and 297,000,000 hooks fished per year from 1986-1995, the most recent complete decade of reported effort.

In terms of the Parties involved in the Atlantic longline fisheries, the volume of catch by parties for the same decades is shown in Figure 6. In the first 10-years of the fishery (1956-1965), a total of 770,000 MT of all species caught by longline in the Atlantic was landed . Of this total, the Japanese distant-water longline fishery accounted for 88% of the catch, with the balance taken by coastal longline fishing nations. In the next decade, the number of distant water longline fishing parties had increased with Japan, Chinese Taipei, and Korea accounting for about 80% of the landings which registered 1.18 million MT for the decade. The number of parties reporting longline catches also increased in the second decade, including catches from many coastal states in the Convention area. During the period 1976-1985, the volume of longline catches remained at about the same level (1.19 million MT), although the amount of effort doubled compared to the prior decade. Distant-water fleets from Japan, Korea, and Chinese Taipei accounted for a somewhat lower proportion of the total (about 70%) and landings from coastal state longline fleets increased somewhat. In the most recent complete decade (1986-1995), catches increased to about 1.52 million MT (27% increase), while effort more than doubled. During this decade, catches from flag of convenience and IUU vessels was becoming more apparent (coded as NEI in Figure 6) and there was a large reduction in catch attributed to the Korean fleet Coastal state longlining also developed further in this decade.

Over the 40-year history of recorded longline catch and effort in the Atlantic examined here, fishing effort has increased at a more rapid rate than have reported landings of all species. In terms of nominal hook efficiency, the overall fishery has experienced about a 90% reduction in MT per hook production (Figure 7). Undoubtedly, there are many factors contributing to this, including different efficiency of gear used by different fleets, differences in targeting both within and between fleets, and changes in abundance and availability of the species caught. However, based on several recent stock assessments conducted by ICCAT's SCRS, it is apparent that estimated pattens in fishing mortality rates, which take into account non-abundance related affects on catch rate patterns (to the degree data allow) mirror the patterns seen in the nominal view (Figure 8).



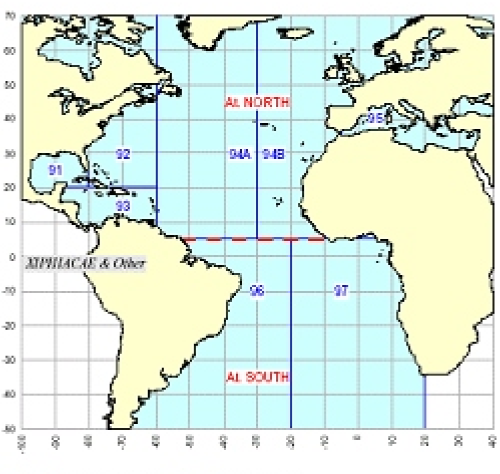
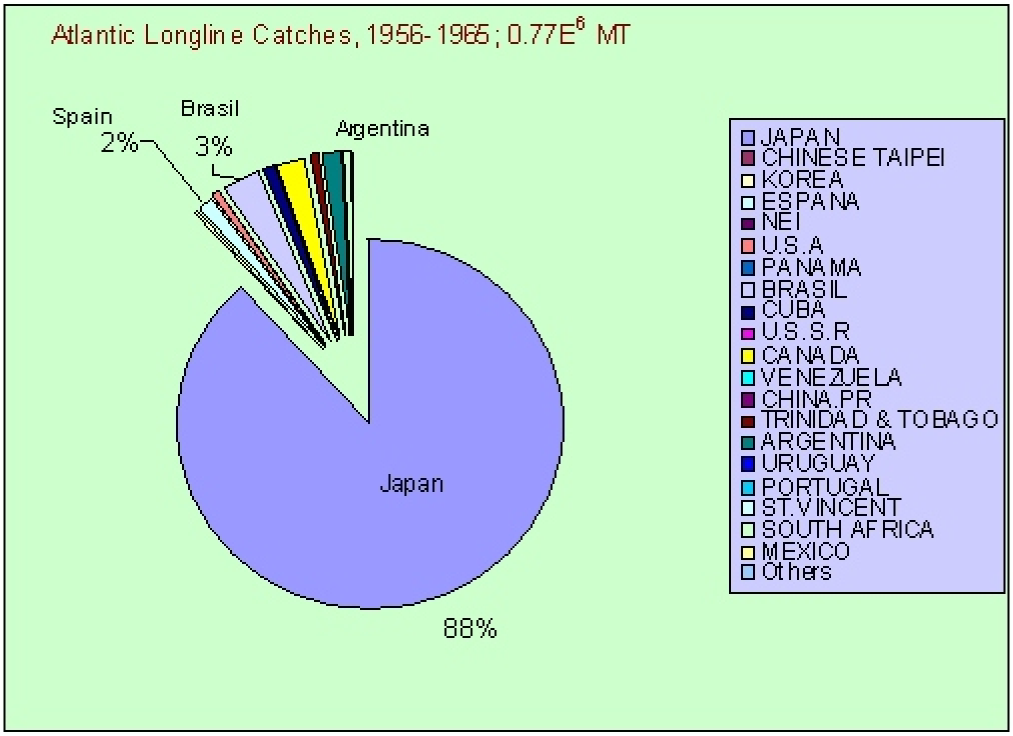


Figure 5. Distribution of nominal reported longline effort in the Atlantic Ocean for the four decades indicated at 5x5 latitude and longitude resolution. In these graphs, the size of the circle is proportional to the number of hooks fished. The percentages indicated represent the proportion of the 40-year cumulative level of reported effort for each decade. The map at the lower left shows the coastlines in the Convention area.

Figure 6. Proportion of total Atlantic longline catch by Party for each of the four decades indicated.



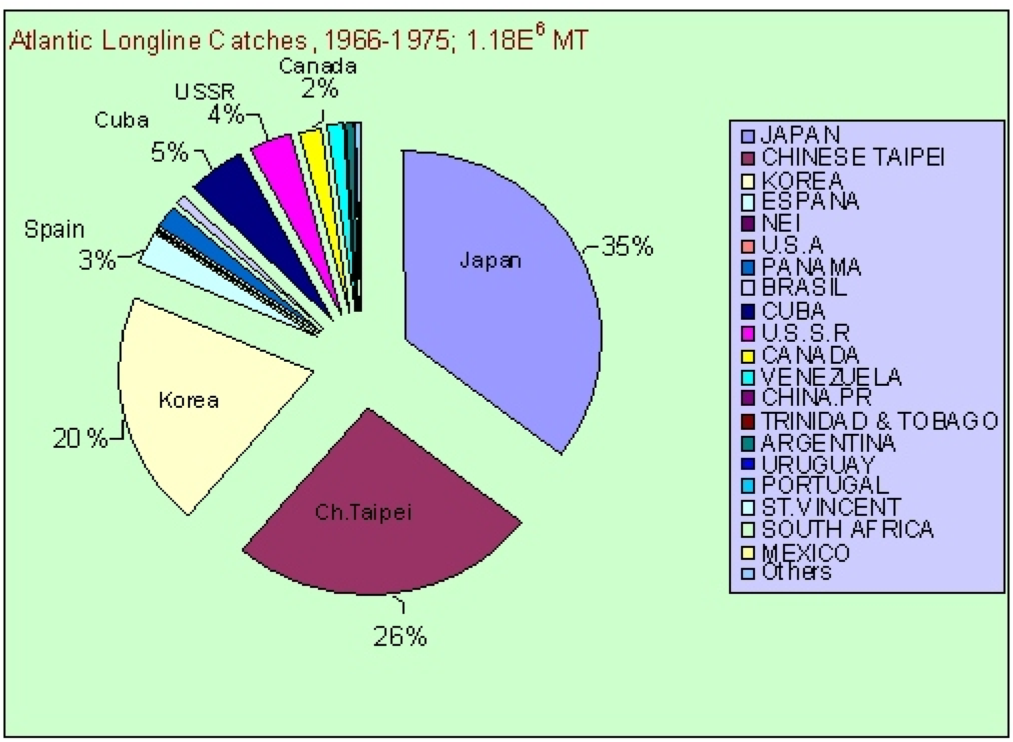
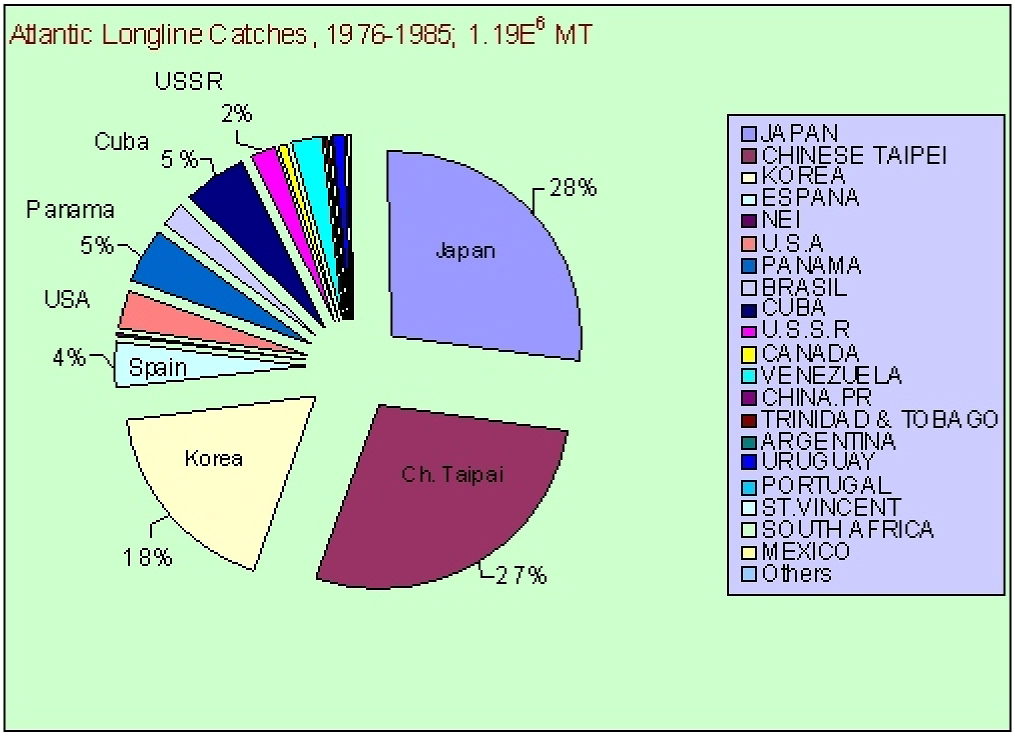
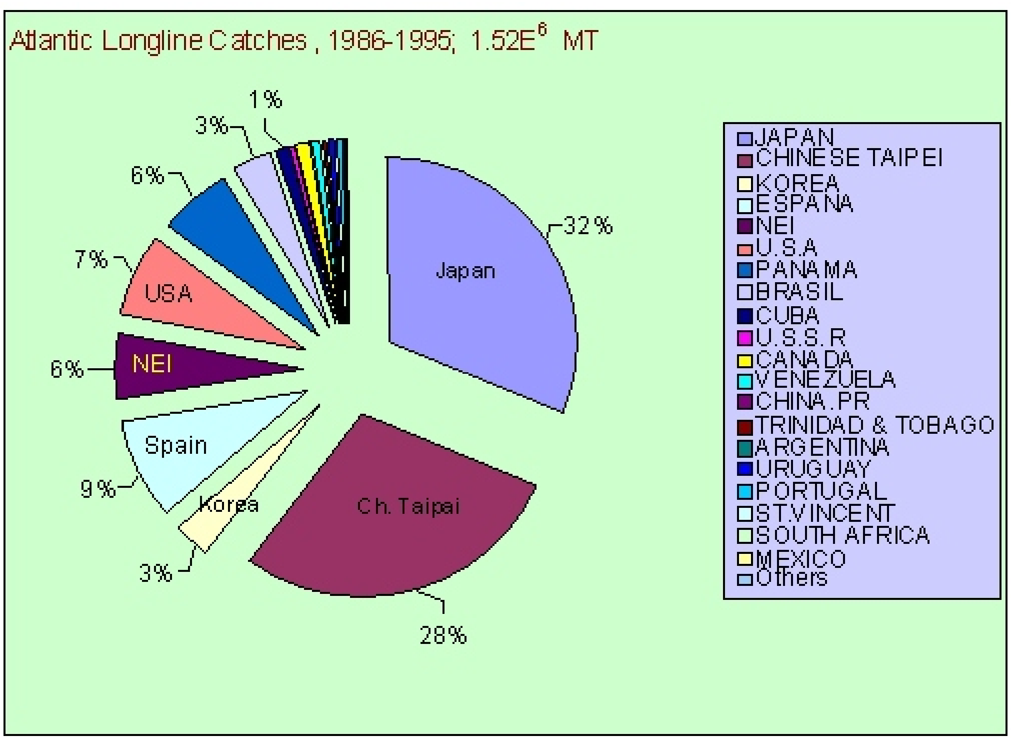


Figure 6. (Continued) Proportion of total Atlantic longline catch by Party for each of the four decades indicated.





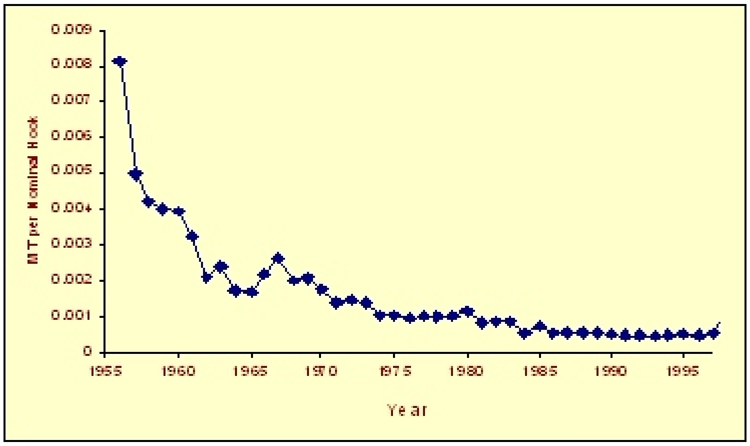


Figure 7. Nominal catch per hook fished by the Atlantic tuna longline fleets 1956-1996.

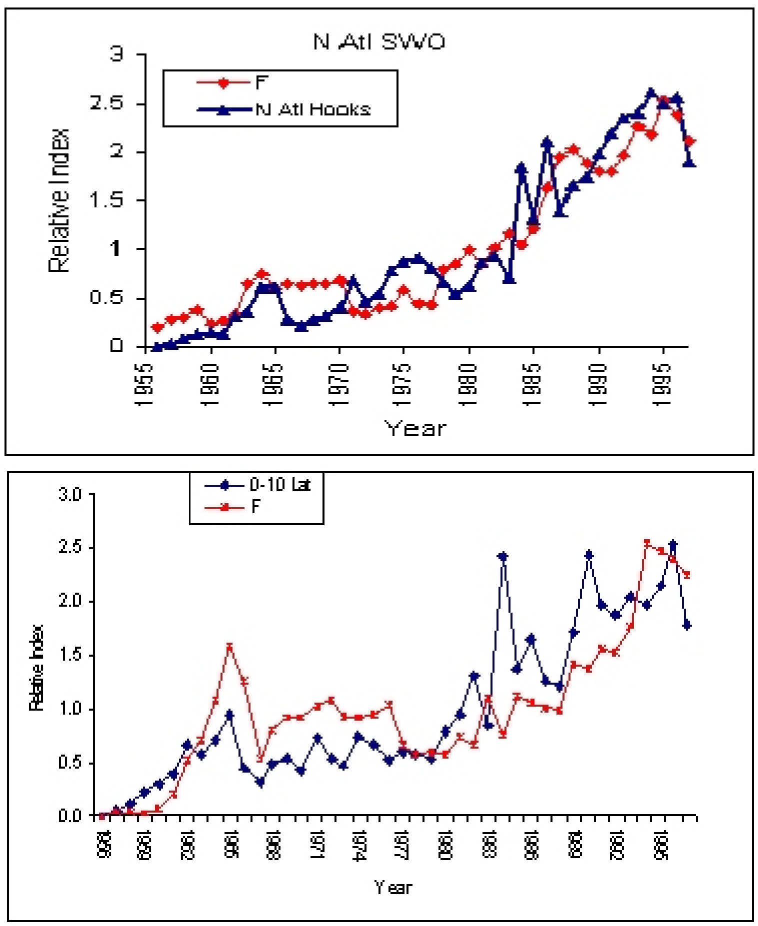
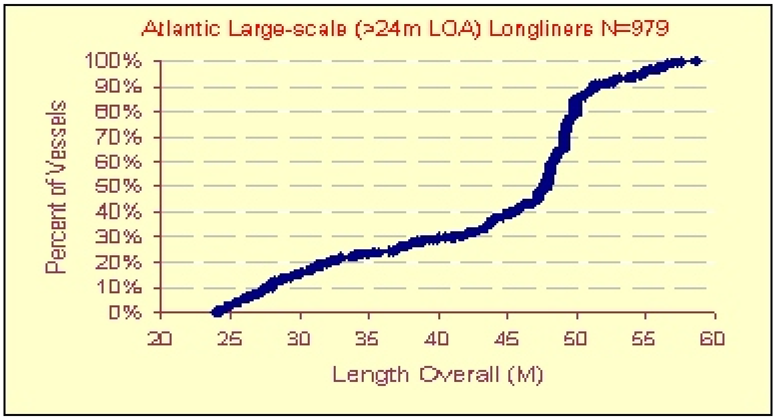


Figure 8. (upper) Estimated pattern in fishing mortality rate (F) for North Atlantic swordfish compared to nominal reported longline hooks fished over the period 1956-1996. (lower) Estimated pattern in fishing mortality rate (F) for Atlantic white marlin compared to nominal reported longline hooks fished in the 0-10 Tropical latitude band over the period 1956-1966.

Characteristics of the Fleets

The Atlantic longline fleet is quite diverse with vessels ranging in size from small, coastal-style vessels of limited range and duration to large-scale longline vessels (>24 m LOA) capable of extended time at sea. Atlantic large-scale longline fleet characteristics are now reported annually to ICCAT in response to recent Recommendations aimed at combating IUU fishing. Of the 979 large-scale vessels reported, LOAs range from 24 to 60 m and GRTs range from 51 to nearly 800 (Figure 9).



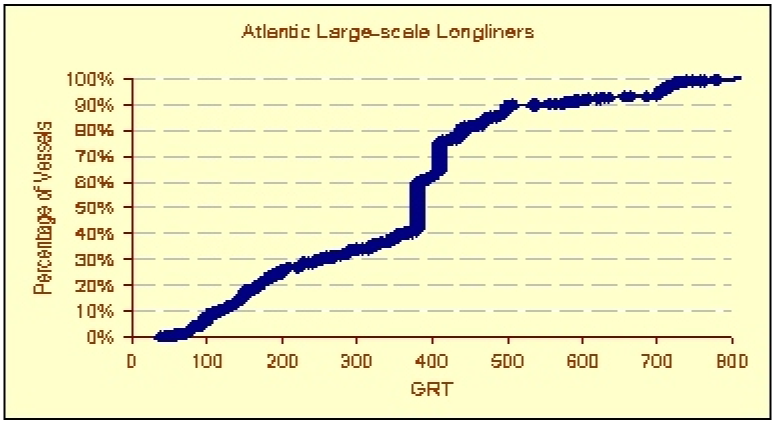


Figure 9. Cumulative percent of LOA (upper) and GRT (lower) characteristics for large-scale longline vessels reported to ICCAT.

The numbers of small-scale and coastal longline vessels is less well documented. The distribution of longline vessel capacity by type of fleet as reported in ICCAT Task I Fishing Power Statistics reveals that the coastal state vessels, on average, are much smaller than the distant water fleet vessels (Figure 10), typically in the 50 GRT or less category.

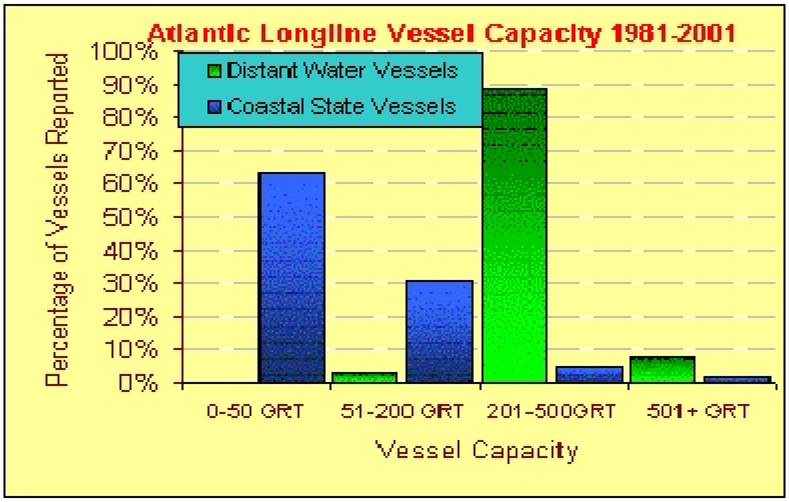


Figure 10. Comparison of the proportion of coastal state vessel GRT and distant water vessel GRT characteristics.

In addition to vessel capacity differences, there are also differences in the amount and styles of longline gear fished by the different fleets. For instance, recent observer data from Japanese fishing vessels indicate that vessels may fish 135 km of mainline and nearly 3000 hooks per daily operation set to fish from 120-250 m deep, whereas vessels in the US fleet might typically fish 50 km of mainline and 700 hooks per daily operation set to fish depths less than 100 m. These differences are known to affect the relative efficiencies for catching different species.

Recent Developments

The operational characteristics of the longline fisheries in the Atlantic and elsewhere has changed, depending on many factors including primary fishery target. One feature of continuing concern and scientific investigation has been the transitioning from shallow to deep-fishing longline gear in the Japanese and other distant-water fleets. These changes impact the gear's efficiency at catching different species. The difference in expected depth of fishing of longline gear is a function of the number of hooks per basket and the gear's interaction with the water column. Existing currents and other factors related to tensions on the mainline will affect the actual depth of fishing by the gear. Active research is underway to help elucidate the relative effectiveness of gear intended to fish at different depths, given knowledge about the target species behavior. As of yet, it is not yet clear how to best integrate the depth-related habitat requirements of different species into indexing their relative abundance using fishery dependent catch rate data.

Another development of concern is the recent increase in IUU fishing activity in the Atlantic as evidenced by substantial volumes of catch recorded through market monitoring systems. ICCAT has undertaken a number of steps to combat this activity, including initiation of a list of vessels which are authorized by Contracting Parties and Cooperating Non-contracting Parties to fish for and land Atlantic tunas and tuna-like species and a list of vessels known or believed to have been involved in IUU activities. Recent indications are that these measures have been effective in reducing Atlantic IUU fishing.

ICCAT has introduced a number of regulations and agreements intended to limit both catch and capacity of the Atlantic tuna fleets and vessel capacity (and effort) reduction programs have been instituted by some nations. It is not yet clear that these reductions will reduce overall fishing effort due to increases in efficiency for the remaining vessels, increases in capacity for developing nations fishing in the Atlantic, technology transfer to low-efficiency fleets, and the potential for continued IUU fishing in the ICCAT area.

Questions and Discussion

Question: What is the relative number of hooks in the Atlantic compared with the Pacific and Indian Oceans?

Response: In the Atlantic, it is estimated that 3 billion hooks were fished over the last decade. On average, around 3 million hooks were fished per year. I can provide numbers to whomever is interested.

OVERVIEW OF LONGLINING IN THE MEDITERRANEAN SEA

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(Written summary prepared from author's powerpoint presentation by the editors)

BACKGROUND INFORMATION ON LONGLINE FISHING IN THE MEDITERRANEAN

- 22 Mediterranean countries
- 15 non-Mediterranean countries
- 2 International bodies manage fishing activities - International Convention to Conserve Atlantic Tuna (ICCAT) and General Fisheries Commission for the Mediterranean (GFCM)
- Different licensing systems (where existing)
- Undefined number of vessels, mostly small size artisanal boats
- Enormous variety of fishing gear
- Year-round activities
- Several thousand harbours and landing locations
- Few landing and catch controls
- Few observer programmes

REGULATIONS

- 2 types: European Commission (EC) countries and non-European Commission countries
- Well-defined rules for EC members with a common base
- Variety of rules for non-EC members
- Difficulty controlling fishing activities of non-Mediterranean countries in the area, particularly flag of convenience or IUU vessels

FISHING ACTIVITIES

- Bottom longlines
  - Undefined number of small vessels (>20,000?)
  - Coastal and deep fishing grounds
  - Long range of target species
  - Small and medium sized hooks

    - Possible low impact on marine turtles
- Surface longlines
    - Possibly >10,000 vessels
    - Drifting and set longlines
    - Small range of target species
    - Medium and large sized hooks
    - Possibly high impact on marine turtles

<u>BOTTOM LONGLINES</u>

- Typical artisanal gear in small-scale coastal fishery
- Deployed on the continental shelf or close to offshore cliffs or seamounts
- Large variety of benthic and benthonectonic target species
- Very low bycatch, often commercial
- Very low quality statistics, due to high number of landing locations and small-scale activity
- Few observer programmes implemented thus far
- Little evidence of large number of marine turtles caught, possibly with minor injuries from small hooks
- Turtles are often released by cutting the line close to the hook

<u>SURFACE LONGLINES</u>

- Utilized by Albania, Algeria, Belize, Bulgaria, China, Croatia, Cyprus, Egypt, France, Greece, Honduras, Israel, Italy, Japan, Lebanon, Liberia, Libya, Malta, Morocco, Palestine, Panama, Philippines, Portugal, Russia, Sierra Leone, Singapore, South Korea, Spain, Taiwan, Tunisia, Turkey, and USA
- Target medium and large pelagic species
- Deployed over the continental shelf (for tuna-like species) or offshore waters (for swordfish, albacore, and bluefin tuna)
- Bycatch includes both commercial and non-commercial species
- Data are available for most important fisheries, but few historical consistent series exist
- Medium-quality statistics are available for most important fisheries
- Trends difficult to estimate due to highly variable factors in each year or fishery
- The bluefin tuna fishery greatly increased in the 1990s, but shows undefined trends due to low quality of the data and several factors affecting CPUE
- The albacore fishery has shown great variation in fishing patterns in recent years; trends are difficult to define but are estimated as almost stable
- The swordfish fishery is possibly the best documented and longlining is now the most important method for catching this species

SURFACE LONGLINES (continued)

- The CPUE trend appears almost stable in some important swordfish fisheries in the last 20 years
- Landing controls are carried out in various harbours, including all EC Mediterranean countries and a few other countries
- Statistical data show a sensible deterioration after the adoption of the bluefin tuna quota regime and the driftnet ban
- The work carried out by scientific observers on board vessels and researchers at landing sites is becoming more difficult, particularly after the adoption of some unbalanced regulations in the Mediterranean Sea
- Data sets used to assess trends of relevant longline fisheries are often mixing East Atlantic and Mediterranean sources and making it almost impossible to understand the fisheries in the Mediterranean
- Several CPUE data sets are shown without considering or noting well known biases or caveats in the data
- Onboard observer programmes carried out by France, Greece, Italy, and Spain have provided good-quality data sets, including detailed lists of bycatch species
- Various species of sharks and rays are often caught on Mediterranean pelagic longlines, but many are released alive. The blue sting ray is the most commonly caught species.

MARINE TURTLE BYCATCH

- Turtle species documented as bycatch in Mediterranean pelagic longlines:
  - Loggerhead turtle (*Caretta caretta*)
  - Leatherback turtle (*Dermochelys coriacea*)
  - Green turtle (*Chelonia mydas*)
- Turtle species occurring in Mediterranean waters not documented as bycatch:
  - Kemp's ridley turtle (*Lepidochelys kempi*)
  - Hawksbill turtle (*Eretmochelys imbricata*)
- Loggerheads have the highest bycatch rates with CPUE ranging from 0 to 40.77, with an average value of 0.567 (MiPAF-WWF-Aquastudio Research Project in 1998-1999)
- Turtles are usually released by cutting the branch line close to the mainline without bringing turtles onboard
- Marine turtle stranding reports are only available from a few countries, many were recorded with hooks and/or line injuring them
- Bait type, hook size, and length of line are all factors which contribute to the problem and increase the difficulty in solving it

MARINE TURTLE CONSERVATION ISSUES

- The number of proper nesting beaches is decreasing from year to year due to anthropogenic pressure
- Presence of lights near nesting beaches reduces reproductive success
- Total lack of knowledge about possible population size of Mediterranean stocks
- Migration patterns are poorly understood due to very few satellite tagging programmes
- Presence of the most occasional species in not monitored in various areas
- Post-hooking survival rate is unknown, especially for longlines targeting large pelagic species
- Number of rescue centres is quite limited, restricted to a few countries, and are not supported by national governments
- CITES regulations do not consider fishery related problems and make data collection more difficult

POSSIBLE SOLUTIONS

- Promote a training course for Mediterranean marine turtles to educate UNEP
- Increase awareness among fishermen, particularly in some southern and eastern Mediterranean areas
- Collect more data, specifically improve the number of onboard observer programmes
- Increase the number of trials with more environmentally-friendly hooks
- Research and develop a new type of metal for longline hooks that biodegrades within a few days in a particular environment

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Questions and Discussion

Question: Why has the adoption of unbalanced regulations made it difficult to promulgate observer programs?

Response: The longline fishery in offshore waters is not regulated on both sides of the Mediterranean Sea. Some fisheries are banned off the European Community's (EC) coasts, but not off Africa in the southern Mediterranean. EC countries have observer programs, but it is difficult for non-EC countries to get funding to support these programs.

PLENARY MODERATED DISCUSSION

Session: Global and Seasonal Distribution and Effort, Gear Configuration, Target Species, and Effort Trends

***Data Availability and Accessibility*:**
Participants noted that data do exist for some areas, such as the Eastern Pacific, and additional studies are underway within the Inter-American Tropical Tuna Commission (IATTC) and Indian Ocean Tuna Commission (IOTC). These data are not yet readily available under the IATTC or IOTC data collection regimes, but could possibly be mined to better define fishing effort. Participants agreed that data may be out there, but are formatted such that they cannot be readily developed for analyses. It was also pointed out that most data collected nationally are kept confidential by the country of origin until official approval is attained, and even then data may only be released in summary form.

***Data Gaps and Data Collection*:**
Several participants commented that the lack of complete data sets on global fishing effort inhibits our ability to see the whole picture. Additionally, wide variability in data collection methods impedes comparison among and between fleets. One participant noted that dolphin bycatch in the Eastern Tropical Pacific is very complex and data are hard to tease out of the overall database. It was suggested that perhaps this community can build off that system and develop an initial set of protocols detailing key items, which should be collected for gaining insight into marine turtle interactions with longline fisheries. Another participant noted that UNCLOS and other international conventions could likely address data collection if resources, e.g., funding and staff, were available. Other participants noted that while this is a good long-term goal, some species of sea turtles, e.g., Pacific leatherbacks, are in serious decline and it may be necessary to take action in the absence of complete data. In such cases, historical data could provide useful information.

Regarding the Overview of Longlining in the Pacific and Indian Ocean presentations, participants commented that fishing effort of coastal South American fleets was not included in the overall effort. It was also noted that fishing effort directed at sharks is not reported through IATTC or IOTC. When asked whether Costa Rica collects information from all vessels fishing under the Costa Rican flag, one participant noted there are approximately 500 Costa Rican vessels that keep some records. However, landings data are not recorded from non-Costa Rican flagged vessels that ship through Costa Rican ports. This is likely occurring throughout all four ocean basins.

Additionally, participants noted that the artisanal component of fisheries has not been adequately incorporated into discussions on bycatch. One participant stressed the importance of discerning the relative proportion of coastal versus deep water fisheries and their respective effects on sea turtles - implying that coastal fisheries adjacent to nesting beaches are affecting turtles more than deep water fisheries. However, turtles on nesting beaches represent a very small part of the life history of sea turtles. It was also noted in later discussions that spatial and temporal aggregations of turtles occur primarily offshore, which corresponds to the highest observed bycatch per unit effort estimates.

Participants noted that hook sizes and types across all fisheries are unknown and this information is necessary to expand turtle bycatch data across fishing effort and fleets. Similarly, participants noted that baiting technique (e.g., threading) is an important characteristic of how the gear fishes, but is probably overlooked by most entities that collect data. Several individuals questioned the existence of databases complete enough to tease out the characteristics of specific gear to determine whether these characteristics are likely to impact turtles and, if so, at what level these impacts might occur.

Participants also noted that data which are being used currently are coming from limited sources, yet this small amount of available data is greatly affecting particular fisheries. Lack of data and misinterpretation of data are a large problem. This issue should be addressed holistically. Furthermore, fishers will not willingly supply data if these data will be used against them. Governance bodies must try and gain fisher's trust by using data to help fishers reduce bycatch rather than closing fisheries. Thus far, most solutions suggested do not include fishers.

The FAO Expert Consultation on Standardization of Data formats and Procedures for Monitoring, Control and Surveillance (MCS) was discussed. The consultation will occur in 2004, but date and venue have not yet been determined. One participant remarked that while everyone is in favor of standardized data collection in the abstract, opinions highly differ on what "standardized" forms should include. Another participant mentioned that much work has already been done on standardizing data collection, however, it may be more important to focus on processing these data for dissemination. This issue will be taken up at the next Committee on Fisheries (COFI) meeting, but is unlikely to go far.

Most fishers also support similarity among forms, especially in light of the increase in the number of observer programs. However, participants noted that one standard form may be impractical because experience and education levels are highly variable among fishermen. Forms would need to be translated into multiple languages to ensure maximum participation.

***Observer Programs*:**
Participants commented that fishermen are unlikely to report catch of non-commercial species, even if they are aware of problems. Some fishermen do report, but there are no estimates of what percentage of fishers are voluntarily reporting. Thus, observer programs are necessary to elucidate reliable estimates of bycatch. Another participant noted that until observer programs are instituted and commonplace, data are generally considered confidential because it may not represent the true picture. Furthermore, establishing these programs is a difficult political issue.

Participants noted that the design of observer programs is important relative to its purpose, i.e., it is possible that real-time data could be disseminated to fleets to enable avoidance of "hot spots". Participants commented that in many cases the current design of observer programs is not statistically rigorous, which is primarily due to lack of funding. Existing programs have been adapted based on levels of funding and subsequently lost statistical power. Although, some countries, e.g., Japan, Korea, Taiwan, U.S., with large commercial fleets already maintain sufficient data collection programs, which could be adjusted to collect additional data necessary to refine bycatch estimates.

Participants further discussed the level of observer coverage required to estimate turtle bycatch and stressed the importance of having adequate coverage. One participant noted that an observer must be on board to get detailed data (e.g., where turtles are caught). These details are imperative for understanding how gear is fished and how that relates to sea turtle bycatch. Some RFMOs are attempting to obtain commercial data, but haven't yet begun to assess the level of detail needed to elucidate why interactions are occurring.

Participants with experience in the Mediterranean commented that hooked or entangled turtles are generally not taken onboard, rather the line is cut, therefore it would be very difficult to use logbooks. Observers could more effectively release turtles and keep track of the fisheries characteristics. Mediterranean participants also felt that observers operating in the Mediterranean were extremely precise.

***Other Threats to Sea Turtle Populations*:**
Participants responded that many threats, such as beachfront development, endanger sea turtle populations. All threats must be addressed simultaneously to affect change, including other fisheries, such as gillnets. Others agreed that no threat can be excluded when populations are in serious decline. Another participant commented on the successful conservation of olive ridleys due to tandem measures, which addressed poaching on nesting beaches as well as bycatch in trawls.

One participant questioned how fisheries bycatch relates to other threats, in terms of relative importance. Similarly, he questioned how longline bycatch compares with bycatch in other fisheries. One participant commented that for some species in some areas, we are addressing all known threats, but the situation is not improving. One participant brought up whether money and effort should be spent determining the relative importance of longlines versus other threats or on data collection for defining specifics needed to solve the problem of bycatch.

Another participant reminded the group that nesting beaches constitute a small portion of the life history of turtles. While this life history stage is generally well studied, looking at numbers of nesting females in real time does not adequately capture what is occurring at the population level. It is important to remember that there is a time lag until eggs develop, mature, and, as adults, reproduce and contribute to the population. Additionally, one participant noted the relative importance of each life history stage to the overall status of the population; this is important when weighing various threats. Another participant commented that this particular workshop was limited to three days and there was insufficient time to consider the threats encountered during the entire life history of sea turtles if the group wished to achieve the objectives of the workshop. This comment was not meant to diminish the need for conservation efforts in other areas.

***Regional and International Efforts*:**
Participants noted that ICCAT was designed primarily to address target catch species. There has been an ongoing debate within ICCAT regarding bycatch, specifically whether ICCAT is the appropriate organization to address this issue, considering lack of funds and staff resources.

The lack of data collection by regional and international bodies is similar for seabirds, although the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) does collect some information. Participants agreed that some existing RFMOs are not set up for large-scale data collection programs, but others are, such as CCAMLR. Participants suggested modifying RFMO charters or developing new entities which are capable of these efforts. Participants commented that a new international approach could be time intensive; it might be useful if States exercised authority over nationally flagged vessels to focus domestic actions more broadly. Similarly, another participant indicated that the U.S. has exercised its authority over domestic vessels to protect turtles and other nations should do the same. Participants further discussed using bi-lateral or multi-lateral mechanisms, such as those utilized with the drifnet fishery, to protect migrating turtles in known corridors throughout international waters. One participant noted that Japan and Taiwan worked together to craft closures for reducing salmon captures. In this case, the closure moved north following the salmon migration. This approach to regional agreements may be applicable to longline bycatch issues. Although, some sort of regime would need to be instituted to enforce regulations and ensure compliance.

***Spatial Considerations (e.g., habitat, fishing location)*:**
Participants noted that in addition to hook type and location of effort, we also need to define habitats utilized by turtles and discern how this relates to mortality and bycatch per unit effort. Participants listed several key pieces of data that might be useful:
- Proportion of coastal versus pelagic longline gear
- Spatial and temporal concentrations and movements of turtles (e.g., migratory corridors)
- Differences in population status of all marine turtle species between ocean basins
- Real-time satellite tagging/tracking of turtles.

Participants suggested tagging hundreds of turtles to elucidate movements in real-time and, therefore, provide fleets with this information, so they could avoid certain areas. This approach could also be implemented relatively quickly. Others questioned what mechanism might be used to keep fishers out of certain areas in real-time. One way might be through international treaties or conventions. Participants commented that data needs differ between species and geographic areas and, therefore, suggested prioritizing to address critical areas first. One person pointed out the value of a comparative approach between different areas with the same problem. Taking advantage of spatial variability and teasing out comparative issues would allow for real power within the data. Participants noted that while focusing on the given task, the group should keep in mind the distribution of fishing effort and turtle species.

***Other*:**
A question was raised as to whether it is known if hooked or entangled turtles are dead or alive when the line is clipped. Participants responded that turtles are generally alive when interacting with shallow water fisheries because turtles are able to reach the surface and breathe. Additionally, it was noted that turtles are generally taken during the process of hauling gear.

A participant questioned whether bottom longline impacts should be considered during this workshop. Others responded that bottom longlines were up for discussion. One participant noted that bottom longline fisheries operate very deep in certain areas and incidental captures result primarily in dead turtles.

To conclude, the group discussed using a suite of solutions, or multiple methods, such as those discussed in this session, to reduce sea turtle bycatch in longline fisheries.

OVERVIEW OF GLOBAL LONGLINING

PART II: EXISTING REGULATORY REGIMES

ORAL PRESENTATION
AND
PLENARY DISCUSSION

INTERNATIONAL FISHERIES INSTRUMENTS

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As the world's population continues to increase, so has the demand for protein from fisheries resources. One particular result is that incidental bycatch of non-target species, including sea turtles, has decreased such populations overall. Destructive fishing and habitat alteration have contributed to further depletion of stocks. Outlined below are examples of international treaties, organizations, and voluntary regimes negotiated to conserve and manage the world's fisheries resources to ensure sustainability for years to come. This presentation is designed to provide background for discussion of how the conservation and management of sea turtles fits into the existing legal framework of international fisheries agreements and organizations.

Recognizing that the oceans occupy 70% of the landmass of the earth and serve as a proxy for the global environment, policy makers and government officials set about creating a "Constitution for the Oceans." This international agreement, or "United Nations Law of the Sea" (UNCLOS) was adopted in 1982 and entered into force in 1994. UNCLOS includes provisions to address conservation and management of living resources, pollution prevention, reduction and control, vessel pollution, and environmental management. In additional to outlining general conservation measures, UNCLOS establishes areas of jurisdiction, including a division between a country's 200 mile Exclusive Economic Zone (EEZ) and the territorial high seas. UNCLOS also establishes guidelines for how to handle dispute resolutions. Although the United States is not a party to the convention, we still recognize its provisions as customary international law.

One of the characteristics of UNCLOS is to serve as an umbrella convention that brings other international rules, regulations, and implementing bodies within its canopy (International Environmental Law, 1997). In 1993, the United Nations (UN) Food and Agriculture Organization (FAO) High Seas Fishing Vessel Compliance Agreement (Compliance Agreement) was negotiated to provide a set of guidelines for how countries should monitor and control their vessels. The Compliance Agreement applies to high seas only and outlines "flag state" responsibilities, including specific authorization and ways to prevent vessels from undermining agreed fishery conservation and management measures. As part of this agreement, the FAO is to maintain a database of all high seas fishing vessels.

The UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement) was negotiated in 1995 and establishes guidelines for countries to resolve instances when fish cross multiple EEZs and are captured by one or more countries. This agreement applies to areas in EEZs as well as the high seas, but only to straddling and highly migratory stocks. The UN Fish Stocks Agreement strengthens UNCLOS rules on fisheries, addressing issues of compatibility, enforcement, and dispute settlement while encouraging countries to take a precautionary approach to fisheries management.

In contrast to the Compliance Agreement and the UN Fish Stocks Agreement, which are legally binding, the FAO Code of Conduct is a voluntary agreement. Drafted in 1995, the Code of Conduct serves as a model for countries to strive for in the management and prosecution of all fisheries everywhere (e.g., capture fisheries, aquaculture, etc.). The Code of Conduct is based on rules of international law, including UNCLOS, and provides principles and standards to help ensure sustainable fisheries practices.

In order to address the growing number of issues related to international fisheries, the FAO created the Committee on Fisheries (COFI), a multilateral forum for exchange of information, negotiation of global plans of action, and technical development. FAO and COFI are not regulatory or management organizations, but instead serve as a venue for technical information dissemination as well as to engage countries not represented elsewhere. Under COFI and the FAO, voluntary instruments elaborating specific aspects of the Code of Conduct were agreed upon and came to be known as International Plans of Action (IPOA). Currently there are four approved and adopted IPOAs: the IPOA for the reduction of the incidental take of seabirds in longline fisheries (1999), the IPOA for the conservation and management of sharks (1999), the IPOA for the reduction of excess fishing capacity (1999) and the IPOA to deter, prevent and eliminate illegal, unreported and unregulated (IUU) fishing (2001). As part of the IPOAs, countries are called on to develop National Plans of Action to implement the plans locally.

As a way to further develop international law and address issues of regional concern, regional fisheries management organizations (RFMO) have been established both bilaterally and multilaterally by international agreement. These RFMOs are tailored to address the specific needs of the members and the commercially valuable fish stocks of a given region or sub-region. As with all international agreements, compliance and enforcement are a large part of the RFMO function. Three of the largest RFMOs are: the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Inter-American Tropical Tuna Commission (IATTC) and the recently-negotiated Western and Central Pacific Fisheries Convention (WCPFC or MHLC).

ICCAT is the largest RFMO in the Atlantic Ocean and includes 33 parties from around the globe. Parties to ICCAT are currently discussing the scope of the mandate of the Commission to determine if it does or should include species other than tuna. As part of this discussion, a draft sea turtle resolution is being considered relating to the collection of data and possible avoidance of interaction, where possible.

In contrast to ICCAT, the IATTC has 13 parties and does not include a significant number of distant water fishing fleets (subsequent to the presentation, one such nation, Spain, has announced its intention to accede, and the current Parties to the IATTC have negotiated a new convention for the region in conjunction with several distant-water countries including Spain and the European Community, Korea, Taiwan, and China). The focus of the IATTC is on the purse seine tuna fisheries of the eastern tropical Pacific, although longlining is one of the fishing techniques under the jurisdiction of the IATTC. As parties to the IATTC, fishermen are required to collect data related to interactions from all fisheries. The Commission encourages crews to follow release guidelines adopted by the IATTC and further encourages the FAO to address data collection.

The WCPFC is a new agreement that has not yet become operational. There are currently 19 signatories from the western Pacific. The agreement includes management of longline fisheries, including highly migratory fish stocks within the convention area. The WCPFC has specific provisions to address bycatch, specifically to "adopt measures to minimize waste, discards, catch by lost or abandoned gear, pollution originating from fishing vessels, catch of non-target species, both fish and non-fish species and impacts on associated or dependent species, in particular endangered species and promote the development and use of selective, environmentally safe and cost-effective fishing gear and techniques."

Although many of the agreements are created for the purpose of conserving and managing fisheries stocks, there are also agreements to address other marine wildlife, including sea turtles. The Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) is a legally-binding treaty that contains provisions to address bycatch from commercial fishing activity. In contrast, the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia is a voluntary instrument to address bycatch and encourage gear use that does not pose a threat to marine turtles. Both of these agreements are relatively new and are among the first real efforts to begin comprehensive management of marine turtles on a regional multilateral level.

There are a number of international instruments that already possess or will develop capacity to directly address sea turtle bycatch in longline fisheries. However, new measures will take time to develop and implement through current multilateral systems. As these measures continue to evolve, they need to include fishing countries and encompass many of the entities already present in the international framework to ensure their success.

PLENARY MODERATED DISCUSSION

Session: Existing Regulatory Regimes

***Turtle Excluder Devices*:**
One participant pointed out that turtle excluder devices (TEDs) are a good working model for how to address an international bycatch issue. The approach of the U.S. requires other countries to use TEDs or develop a comparable measure to achieve bycatch reduction. Under Section 609 of U.S. Public Law 101-162 (Section 609), countries cannot export shrimp to the U.S. unless they implement a TEDs or other comparable program. Participants inquired how effective the U.S. has been in promoting the use of TEDs overseas. Representatives from the U.S. Department of State feel the U.S. has been fairly successful based on the number of countries certified to import shrimp into the U.S. Each year, the Department of State certifies countries that have developed an appropriate regulatory regime to reduce turtle bycatch in shrimp trawls. However, many countries that do not export to the U.S. have not addressed this issue. Countries may not be certified to export to the U.S. because they cannot enforce their TEDs regulations, or they choose not to seek certification because the U.S. market is not important to them. Participants noted that similar obstacles may occur as the longline bycatch issue is addressed.

The group then discussed the TED program in Australia and compliance issues. In the Gulf of Carpentaria, TED implementation reduced both incidental turtle captures and mortality. Also in this region, TEDs have increased profits for fishermen. Participants reiterated that many countries lack capacity to enforce rules dockside or at sea. Furthermore, one participant noted that if the group were to develop a suite of measures to decrease bycatch in longline fisheries, it would be a challenge to enforce these management measures. Others commented that industry resistance to change and regulation is highly possible as this issue moves forward.

Discussion continued regarding the restriction of market access to give effect to a conservation measure and how Section 609 relates to the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO). Mr. Hogan discussed the WTO dispute settlement case and explained that the U.S. prevailed in the original decision regarding conservation of exhaustible natural resources, but that the U.S. was criticized in that decision as applying Section 609 in a discriminatory fashion. The U.S. then changed parts of the process by which it certifies countries to export shrimp to the U.S. Participants pointed out that there is less of a world market as it relates to fisheries. This mechanism seems to work best when one country controls a large percentage of the market for a particular product, e.g., the U.S. controls approximately 90% of the shrimp market, but it may not be as effective for products with less market leverage, such as longline-caught species. In the U.S., market access is not a regulatory issue, it can only be dealt with by congressional action or public campaigns. One participant noted that even if the U.S. did have the necessary leverage with longline-caught species, exploring trade restrictions at this point would be premature. The problem is trying to balance economic development with allowing distant water fishing nations to continue fishing as they are now. Most global fishing industries are reluctant to discuss the issue because they are concerned that their fishery could go the way of driftnetting or trawling. Participants commented that the outcome of the driftnet fishery (i.e., closure) and the shrimp fishery (Section 609) are not desirable approaches for the longline fishery, but instead a multi-lateral approach is preferred.

***UNCLOS*:**
One participant brought up the United Nations Convention on Law of the Sea (UNCLOS) and asked for clarification on one aspect of the Convention: That when an organism is "born" in one nation, that nation has the ability to affect that organism's management in other nation's EEZs. Participants noted that this portion of the Convention is not well defined and is subject to much interpretation by parties. The U.S. has applied UNCLOS as customary international law, but has yet to ratify the Convention.

***CITES*:**
The group discussed using the Convention on International Trade of Endangered Species (CITES) as it is now or whether it could be modified to address longline bycatch. The general response from the group was that CITES would not be an effective tool. At the most recent Conference of the Parties, CITES addressed marine species and moving toward a broader, systemic review of marine species by developing a memorandum of understanding (MOU) with the FAO. This MOU will work towards making CITES a more effective tool for fisheries managers.

***Convention on Migratory Species*:**
Participants then shifted the discussion to the Convention on Migratory Species (CMS). CMS is a binding agreement that covers migratory species such as sea turtles and which could be useful, even though not all DWFNs are parties.

***Inter-American Convention on the Protection and Conservation of Sea Turtles*:**
Participants inquired how the IAC affects certification of countries that do not have TED laws. The IAC is separate from the unilateral TEDs program of the U.S. A country can meet all the terms of the IAC, but still be subject to TED certification for access to the U.S. shrimp market. Participants questioned whether the IAC provision, which prohibits trade sanctions between member nations, is consistent with the WTO decision on Section 609. From the U.S. point of view, the IAC provision is separate in terms of implementation.

Participants asked what happens to non-parties when a convention enters into force. Non-signatories can either declare cooperation and agree to abide by the provisions of the convention or not. Participants noted that this has not been a significant problem in the past. However, RFMOs are increasingly applying pressure to non-cooperating countries because they undermine the effectiveness of agreements. Others noted that as more countries are willing to address enforceable measures, the consequences of not cooperating will likely become more severe.

***International Plans of Action*:**

The discussion moved onto IPOAs and participants stated their opinions on this subject. During the presentation on existing regulatory regimes, Mr. Hogan summarized the pros and cons of IPOAs or non-binding plans of action. This policy tool can solidify international positions, but in the end, the effectiveness of an IPOA is up to individual countries. For example, some countries have yet to develop action plans even though they largely participate in activities that fall within the scope of an existing IPOA. Participants noted that lack of full participation by all countries could decrease the effectiveness of an IPOA. Furthermore, others suspect that as the number of IPOAs increases (currently there are four), the more difficult it becomes for individual countries to keep up. One participant pointed out that the IPOA for sharks has resulted in submission of some data that might not otherwise have been reported. Additionally, under an IPOA, countries can receive technical assistance to develop an action plan and implement its components. Another participant further explained that the shark IPOA has not come very far during years of work since the FAO does not have the personnel, resources, or capacity to commit to many IPOAs. However, FAO does provide an opportunity for common ground and a forum for discussion to catalyze efforts on sea turtle bycatch in longline fisheries.

To date, only two countries have finalized their National Plans of Action (NPOA) on seabirds, while approximately 5-10 countries are in the process of developing plans. Several have received financial assistance to develop NPOAs, but there are at least 10 countries that should be developing them and are not. An IPOA provided a platform for the seabird-longline issue that did not previously exist. The seabird IPOA was adopted in 1999 and spawned the first International Fishers Forum (IFF1) in 2000. The concrete actions committed to during IFF1 and IFF2 would not have been possible if not for the IPOA. Participants felt the seabird IPOA timeline was probably a bit optimistic. One participant cautioned the group that it may be a bit premature to consider an IPOA since the seabird IPOA had an appended toolbox with proven bycatch reduction measures that are not yet available for sea turtles.

IPOAs are beneficial in that FAO recognizes the problem and initiates discussion and examination of data. One participant explained that any IPOA failure would be due to individual countries, not FAO. IPOAs can serve as organizational fronts, possibly used to develop technical manuals. Conversely, in a given country, IPOAs may be dealt with under the jurisdiction of the environmental ministry as opposed to the fisheries ministry, which may result in a negative response from the fishery side. Additionally, participants noted that regulatory action is generally imposed on countries that provide data, but countries that do not supply data are often not regulated.

According to some participants, currently at FAO, there is “IPOA fatigue.” The fifth IPOA under development focuses on status and trends. Participants were concerned that if an IPOA on sea turtles is adopted, it will act as a deterrent to effective action by nations and a justification to sit back and not take further action, as in the case of CITES shark listings. Most didn’t want an IPOA because this issue is too important for countries to ignore. Participants suggested crafting concrete actions at this workshop, which FAO can be part of, but possibly moving away from an IPOA.

A participant inquired whether any consideration was given to securing funding through the Global Environmental Fund during the IPOA process. No consideration was given during the Seabird IPOA development, however, there was a subsequent workshop to develop a grant system regionally, not for the entire IPOA.

***Other*:**
Some participants noted that progress is not being made on the international front despite the existence of two sea turtle conventions and the MHLC. The sea turtle conventions' memberships do not include distant water fishing nations and the MHLC has not yet entered into force (21 out of 25 countries necessary have ratified the convention). Not all the major distant water fishing nations are parties to the existing binding international agreements, e.g., UNCLOS provision relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. One common response the U.S. gets when asking these nations to join internationally binding agreements is: "Why hasn't the U.S. ratified UNCLOS?"

Participants also voiced concerns related to illegal, unreported, and unregulated (IUU) fishing.

OVERVIEW OF MARINE TURTLES AND LONGLINE FISHING

ORAL PRESENTATIONS
AND
PLENARY DISCUSSION

LIFE HISTORY AND POPULATION STATUS OF SEA TURTLES IN THE PACIFIC

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Introduction

Declining sea turtle populations have been the focus of international concern and conservation effort for a number of years under the IUCN. Kemp's ridley, hawksbill, and leatherback turtles are considered Critically Endangered; loggerhead, green, and olive ridley turtles are listed as Endangered; and flatbacks are considered Vulnerable (Meylan and Meylan 1999; IUCN Red List 2000). The Convention on International Trade in Endangered Species of Flora and Fauna (CITES) lists all sea turtles in Appendix I, so that they are prohibited from international trade from or to signatory countries (Pritchard 1997).

Human interactions have been the primary cause of these population declines. Sea turtles and their eggs are prized world-wide for human consumption, their oils have been used for lubricants and ingredients in cosmetics, and their shells used for jewelry and eyeglass frames. Nonetheless, mass slaughter of turtles and plunder of their nests have been and remain a prime cause of population declines; encroachment of human populations into coastal habitats further contributes to population declines by degrading nesting beaches. Harvesting of sea turtles for subsistence or commercial purposes and incidental mortality in commercial fishing further diminishes sea turtle populations. Longlining is one of several forms of fishing that impact sea turtles. This paper provides a general overview of the life history of sea turtles and summarize the state of knowledge on the stock ranges and population status of sea turtles in the Pacific, with emphasis on loggerheads, leatherbacks, and olive ridleys, the three species most likely to be impacted by pelagic longline fisheries.

General Life History of Sea Turtles

Seven species of sea turtles in two families are recognized: (1) loggerhead (*Caretta caretta*); (2) Kemp's ridley (*Lepidochelys kempii*); (3) olive ridley (*Lepidochelys olivacea*); (4) hawksbill (*Eretmochelys imbricata*); (5) flatback (*Natator depressus*); (6) leatherback (*Dermochelys coriacea*), and (7) the green turtle (*Chelonia mydas*). In addition, there is controversy over the status of the distinctive eastern Pacific populations of green turtle considered by some to be a separate species, *Chelonia agassizii*.

Sea turtles inhabit every ocean basin, with representatives of some species found from the Arctic Circle to Tasmania. Hawksbills are perhaps the most tropical of the sea turtles, whereas leatherbacks are known to travel into colder, sometimes polar, waters. The majority of sea turtles are distributed world-wide, except for the flatback, which is restricted to Australia, and the Kemp's Ridley, which occurs in the Gulf of Mexico and the North Atlantic (Pritchard 1997; Meylan and Meylan 1999).

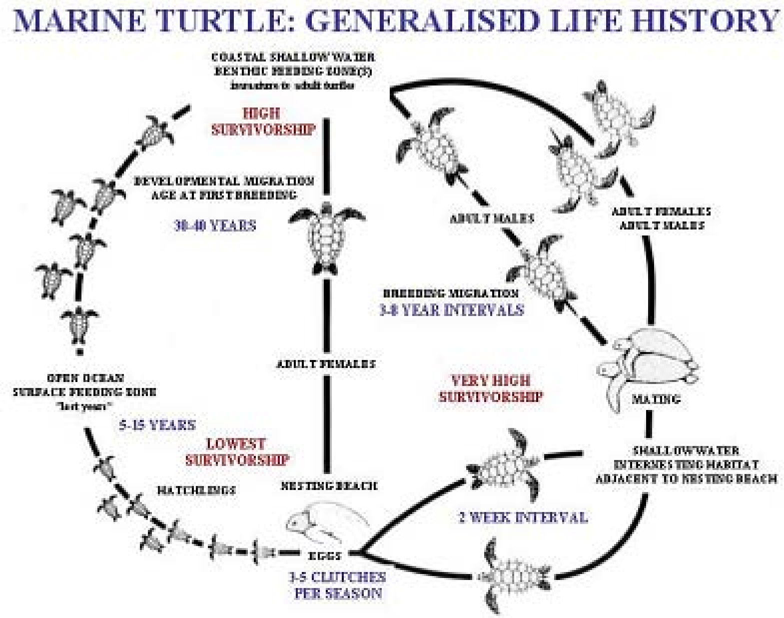

Figure 1. Generalized life history of sea turtles (figure from C. Limpus). Note that leatherbacks and olive ridleys lead more pelagic existence as adults than is depicted in this schematic (see text).

Migration habits differ among sea turtle species. Migrations may range from a few to thousands of kilometers, and differ among species and also among different populations of the same species. Some sea turtle populations nest and feed in the same general areas; others migrate great distances. While each species has specialized dietary and habitat requirements that reflect adaptations to different ecological niches (Henderickson 1980), all generally have the same life history cycle (Figure 1).

Females come ashore seasonally to lay their eggs - as many as 15 clutches of 50-150 eggs over a 3 to 6 month period - which develop and hatch in the sand on tropical or sub-tropical beaches. Incubation time varies, but for most species is 45 to 70 days. The sex of an embryo is determined by the incubation temperature during a critical period spanning the middle third of incubation. Lower nest temperatures produce more males; higher temperatures produce more females.

Eggs hatch after 50-75 days, producing hatchlings that emerge from the sand and immediately scurry to the ocean, and swim out through the surf and offshore. Post-hatchlings enter a pelagic phase during which it is thought they are carried by currents until they settle into developmental habitats

(Figure 1). The duration of this pelagic phase is unknown, but has become known as the "lost year" (Carr 1987) because juveniles of this stage are rarely seen and little is known about it. The duration of this phase is most likely several years during which they are most likely carried by prevailing surface currents, living in floating seaweed, or in oceanic convergence zones where they are camouflaged and where they can find food. Juveniles "settle" into developmental habitats, which, for some species like Kemp's ridley and green turtles, consist of coastal and inshore waters. Some, like the leatherback remain pelagic through much of their life history. Sea turtles may take anywhere from 6 years to over 50 years to mature, depending on the species and location.

Once mature, females undertake reproductive migrations from foraging areas to the nesting beaches. These migrations may take them thousands of kilometers. Tagging studies have shown that females tend to return to the same beach in subsequent years and it is generally believed that females return to their natal beaches to nest once they mature. It has not been possible to directly test this theory, sufficient evidence has accumulated from genetic studies that indirectly support natal homing, and this model is now generally accepted. Although the precision of this homing, which in turn defines stock boundaries, appears to vary between species and geographic regions (Bowen 1995).

The period of time that different species of sea turtles spend in pelagic juvenile and coastal benthic feeding stages will influence the exposure to threats from incidental take in fisheries. Hawksbills make the transition from pelagic to benthic habitats at around 5 years (Limpus & Limpus 2000); green turtles at around 5-10 years, while loggerheads may spend up to 20 years in pelagic habitat. Olive ridleys tend to lead pelagic and benthic lifestyles throughout their later juvenile and adult stages, whereas leatherbacks tend to be almost entirely pelagic. Therefore, in general, loggerheads, leatherbacks, and olive ridleys will be exposed to greater risk of interaction with pelagic longline fishing gear than green and hawksbill turtles. This is reflected in bycatch data that are being collected by fisheries observers in longline fisheries operating in the North Pacific as well in the Southeast Pacific.

In order to assess the impacts of high seas longline fishing on sea turtles, it is important to identify the stocks that are being affected and the status of those stocks. This is difficult to do, since turtles encountered on the high seas may include pelagic juveniles and sub-adults from multiple nesting stocks, adults transiting open ocean on their way from foraging to nesting sites, and non-breeding adults that are meandering around open ocean foraging areas. Molecular genetics, tagging, and satellite telemetry have been useful in helping to define stock ranges.

The Leatherback

The leatherback is the largest of all living sea turtles. Mature leatherbacks reach about 1.2 to 1.9 m (4-6 ft.) and 200 to 506 kg (441-1,116 lb.), with the smaller individuals occurring in eastern Pacific nesting populations. Unlike the hardshell turtles, the leatherback's carapace is covered with skin and an insulating layer of blubber around the neck and shoulders that, along with several other remarkable adaptations, allow this species to thrive in colder waters, ranging circumglobally from 71°N to 42°S latitude in the Pacific and in all other major oceans. Leatherback turtles tend to dive, often to great depths, in a cycle that follows the daily rising and sinking of the dense layer of plankton and jellyfish on which they feed (Eckert et al. 1989).

Leatherbacks are not uncommon in coastal waters, but are primarily considered pelagic. They forage widely in temperate waters except during the nesting season, when females return to tropical beaches to lay eggs. They are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters. Mean age at sexual maturity is estimated around 13 to 14 years (Zug & Parham 1996). The natural longevity of leatherbacks is still unknown, however some nesters tagged as adults over 20 years ago continue to nest regularly, suggesting that leatherbacks remain reproductively active for many years.

Leatherback populations are declining at all major Pacific basin nesting beaches, especially in the past two decades (NMFS and USFWS 1998, Spotila et al. 2000; Figure 4). The major decline of these nesting populations was most likely brought about by a severe over-harvest of eggs coupled with incidental mortality from fishing (Eckert 1997), especially the high seas driftnet fishery in the 1980s (Sarti et al. 1996).

Remaining breeding assemblages occur on both sides of the Pacific. In the Western Pacific region, they occur at low and scattered densities in Papua New Guinea (PNG), Solomon Islands, Fiji, Thailand, Vanuatu, China, and Australia (E and NE) (Limpus et al. 1984; Márquez 1990; Hirth et al. 1993). In the western Pacific the remaining major rookeries are limited to Papua (formerly Irian Jaya, Indonesia), and Malaysia (Terengganu). In the Eastern Pacific, the largest rookeries occur along the coasts of Mexico and Costa Rica. Scattered nesting has been reported in Panama, Colombia, Ecuador, and Panama (Márquez 1990; Spotila et al. 1996).

Mitochondrial DNA (mtDNA) sequences can be used to distinguish western Pacific from eastern Pacific genetic stocks (Figure 2). The East Pacific genetic stock includes Mexican and Costa Rican breeding assemblages, and the West Pacific stock contains populations in the Solomon Islands, Papua (Indonesia), and Papua New Guinea (Dutton et al. 2002). Genetic results, coupled with tag-recapture and satellite telemetry data, suggest that the nesting stocks in the western Pacific primarily use the North Pacific for development and foraging, while animals from eastern Pacific stocks generally forage in the southern hemisphere, including the waters off Peru and Chile (Dutton et al. 2002). However, this pattern is not exclusive, since animals of western Pacific stock origin have been found off Chile (Donoso et al. 2000), and likewise, some leatherbacks of eastern Pacific stock origin are found in the North Pacific (Dutton et al. 2002).

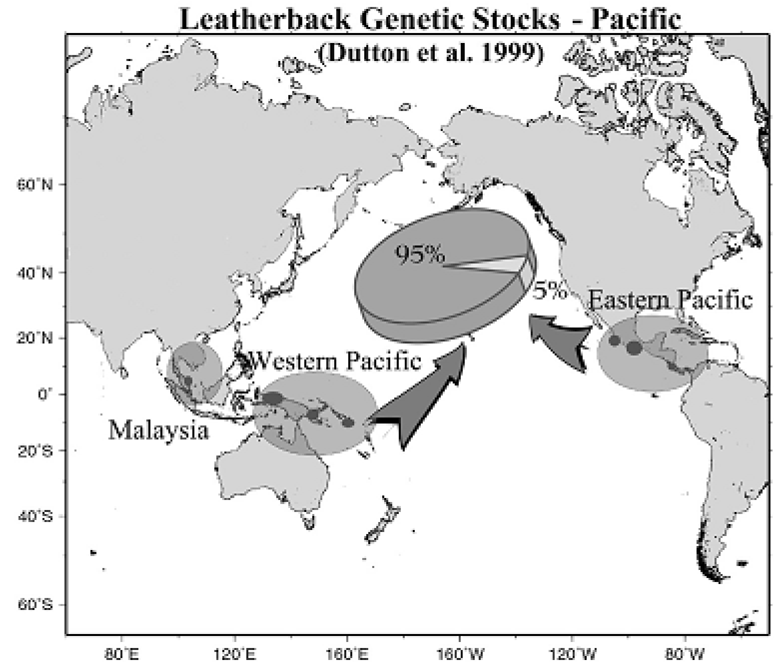

Figure 2. Stock composition of leatherbacks encountered in the North Pacific based on mtDNA analysis (17 samples collected from the Hawaii-based longline fishery). The eastern Pacific genetic stock includes nesting populations in Costa Rica and Mexico, while the western Pacific stocks include populations in Papua (Indonesia), Papua New Guinea, and Solomon Islands, and a distinct stock in Malaysia (see Dutton et al. 1999).

Leatherbacks undertake some of the longest migrations of all sea turtles and can travel great distances between feeding and nesting areas (Figure 3). Although leatherbacks do not nest on the U.S. Pacific coast or territories, they forage in U.S. waters. Animals that are found at these forage areas are mainly from nesting beaches in the western Pacific, and undertake extraordinary migrations across the Pacific to return to nest in Indonesia, Solomon Islands, or Papua New Guinea (Dutton et al. 1999b). This migratory behavior exposes them to several U.S. and international high seas fisheries where they are taken as bycatch. While some eastern Pacific leatherbacks are found in the north Pacific, most animals that originate in Mexico and Costa Rica migrate south to feed in waters off Peru and Chile and farther out in the southeastern Pacific (Dutton et al. 2000; Eckert 1999; Morreale et al. 1994). The juvenile developmental areas remain unknown.

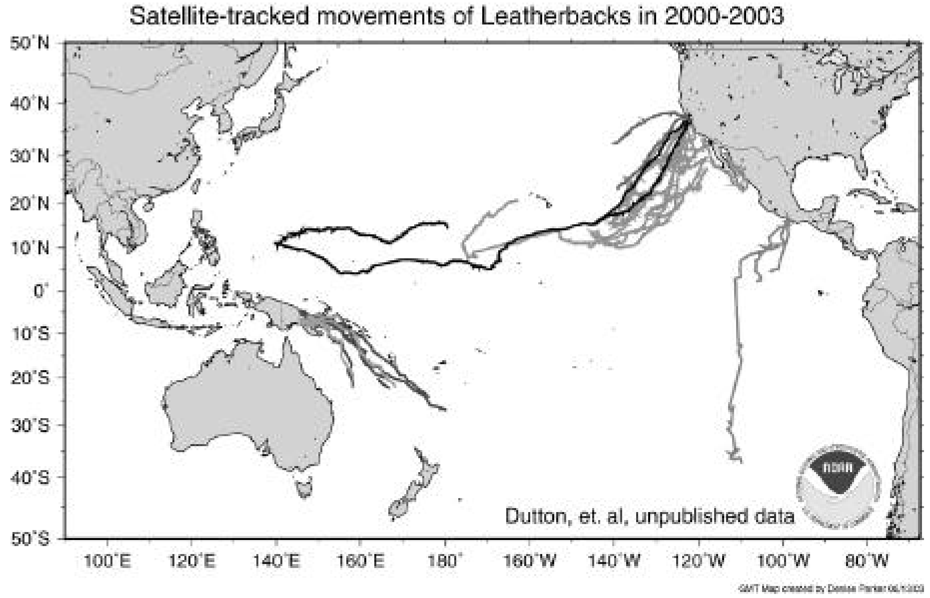

Figure 3. Satellite-tracked movements of adult leatherbacks in the Pacific. Tracks include turtles captured and released on a foraging area in Monterey Bay California (Dutton, Eckert and Benson, unpublished); females from nesting beaches in Papua New Guinea (Dutton, Benson, Rei and Ambio, unpublished); and nesting females in Mexico (Sarti, Dutton and Eckert, unpublished). Additional studies (not depicted here) have tracked southward post-nesting movements of female leatherbacks from Costa Rica passing by the Galapagos Islands (Morreale et al. 1994), and also additional females from Mexico that have traveled to waters off Peru and Chile (Eckert 1997).

The consistency in pathways followed by the majority of satellite-tagged animals indicates that females departing nesting beaches may be following specific oceanic corridors into their pelagic habitats (Eckert 1997) and may follow deepwater bathymetric contours ranging from 200-3,500 meters (Morreale et al. 1994).

Abundance and Trends

Western Pacific

There is some uncertainty over the abundance estimates and trends of rookeries in this region, since not all have been surveyed consistently. Rookery sizes in the Solomons and PNG are estimated to be less than 100 nesting females per year (Dutton et al. 2002). In the western Pacific, the Terengganu population in Malaysia has collapsed. It went from being one of the largest leatherback nesting aggregations in the world in the 1950s, with over 10,000 nests per year (1956), to less than 100 by the mid 1990s - a drop of 3 orders of magnitude in less than 100 years (Chan and Liew 1996; Figure 4).

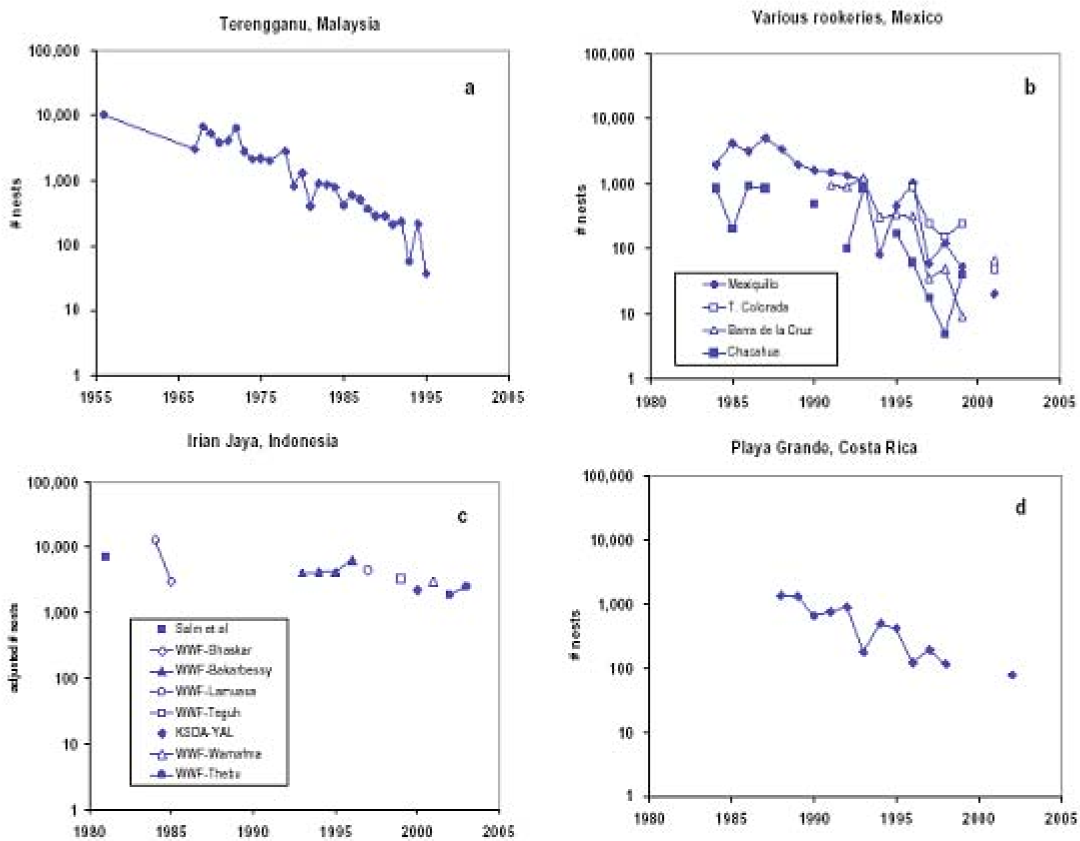

Figure 4. Annual nesting activity recorded at key leatherback nesting beaches in the Pacific. (a) Terengganu, Malaysia 1956-1995 (from Chan and Liew 1996), (b) four index beaches in Mexico (from Sarti 2001); (c) Papua Irian Jaya, Indonesia (from Hitipeuw and Maturborg 2002); (d) Playa Grande, Costa Rica (from Spotila et al. 2000). Note that nesting activity is given as number of nests laid on a logarithmic scale (graphic from Abreu-Grobois, unpublished).

Currently the largest remaining leatherback rookery in the entire Indo-Pacific region nests on the north Vogelkop coast of Papua, Indonesia (formerly known as Irian Jaya), with more than 1,000 females nesting a year (Figure 4). There is some uncertainty over current trends, due to gaps in nesting surveys, however, it appears that nesting activity has declined from historic levels of the early 1980's. The nesting numbers appear to be maintaining at around 3,000 nests per year (Figure 4), however threats from predation by feral pigs, beach erosion, and human encroachment have impacted hatchling production over the last decade. Given the current serious threats to all life stages in the Indonesian region, there is concern that this population may be prone to sudden collapse, as has been seen in other populations around the Pacific.

Eastern Pacific

The eastern Pacific leatherback nesting populations have collapsed in recent years. In Mexico, nesting declined from many thousands of females in the early 1980s, to approximately 50% by the mid-1980s, when continuous beach monitoring began. Currently the total number of nests at these same beaches is less than 200 with no more than 110-120 nesting females estimated for the entire country, and only 4 or 5 females nesting in 2002 at each of the index beaches (Sarti et al. 2002). This decline is similar to Terengganu and has also been seen in Costa Rica (Figure 4).

The Loggerhead

The loggerhead is one of the larger sea turtles and has a characteristic reddish brown, bony carapace which is often covered by epibionts such as barnacles. Its head is comparatively large, adults reach sizes of 95-100 cm curved carapace length (CCL) (Dodd 1988). It is widely distributed across pelagic waters, continental shelves, bays, estuaries, and lagoons in both temperate and subtropical waters (16-20°C).

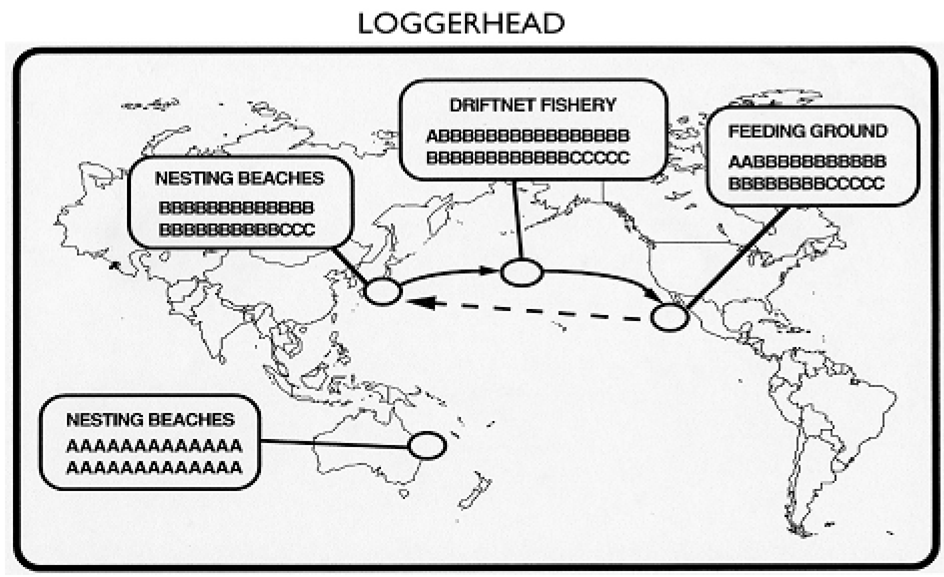

Figure 5. Genetic stock composition (based on mtDNA haplotypes) of loggerheads in the Pacific (from Bowen et al. 1995). Two regional nesting stocks are shown (Japan and Australia). The turtles in the North Pacific foraging areas belong to the Japanese nesting stock.

Breeding areas are restricted to the western subtropical and temperate margins of Japan in the north, and in eastern Australia and New Caledonia in the south (Figure 5). The transition from hatchling to young juvenile in this species occurs in the open ocean. Juvenile foraging areas occur off Baja California, Mexico, approximately 10-12,000 km from their nearest nesting beaches in Japan (Figure 5). The breeding aggregations in the North and South Pacific Ocean (Japan and Australian stocks, respectively) are genetically distinct (Bowen et al. 1995). Ongoing genetic and tagging studies are beginning to define breeding stocks on a finer scale within these broad regions. Within Australia, the cluster of rookeries in the east and west are recognized as two distinct management units by genetic studies (see Dutton et al. 2002). Limpus and Limpus (2003) also suggest an additional unit, encompassing the small rookeries in New Caledonia (1,300km distant from Australian nesting beaches). Similar genetic studies in Japan (Hatase et al. 2002) indicate the presence of at least four discernable management units and provide evidence that all loggerheads found in the North Pacific originate in Japan.

Little is known about the range of reproductive migrations for Japanese adults, but for Australian adults, tag recoveries indicate feeding grounds along the entire Queensland east coast to the Gulf of Carpentaria and Papua New Guinea (Limpus 1982). Telemetry and tagging studies have shown trans-Pacific movements (Uchida and Teruya 1991; Nichols et al. 2000).

Abundance and Trends

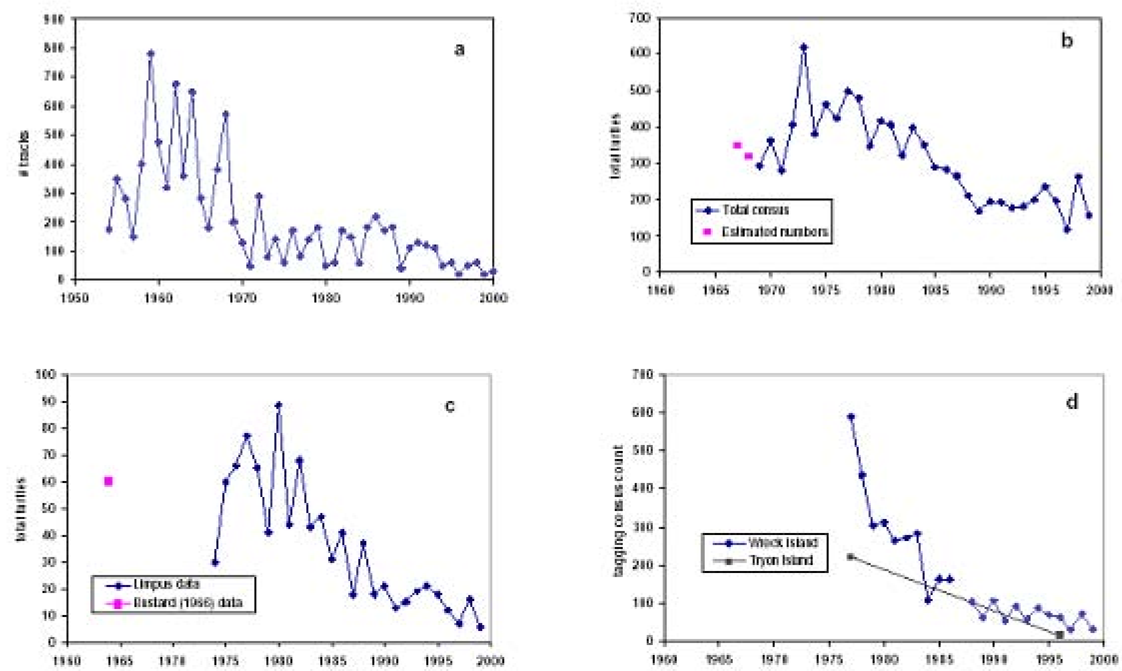

Figure 6. Long-term changes in annual nesting activity at four representative loggerhead index nesting beaches in the Pacific. (a) Kamoda Beach, Japan 1954-2000 (from Kamezaki et al. 2003); (b) Bundaberg coast; and (c) Heron Island, both total annual census from Eastern Australia (from Limpus and Limpus 2003a); (d) Wreck Island and Tryon Island annual nesting indices (2 week census) from Eastern Australia (from Limpus and Limpus 2003a). Note different scales of the axes (graphs provided by Abreu-Grobois).

Northwest Pacific-Japan

Within the North Pacific, the only nesting areas are located in Japan. Although nesting is widely distributed across the 13° latitude, the two major nesting areas are in the Nansei Shoto Archipelago and on the island of Kyushu, both in the South (Kamezaki et al. 2003). Data from Kamoda beach (Figure 6) show that population sizes have decreased significantly (50-90%) since the 1950s; population levels are lower here than in other loggerhead areas with an estimated annual number of nesting females of less than 1,000 (Kamezaki et al. 2003). Number of recorded nests appears to have stabilized after 1998, with around 2,600 nests per year (Kamezaki et al. 2003). Unpublished reports also suggest that nesting at other Japanese rookeries may be increasing.

Pacific Islands

Sporadic nesting may occur in the Solomon Islands and Tokelau (reviewed by Limpus and Limpus 2003). No data on trends are available.

New Caledonia

Annual nesting population size in the southern part of New Caledonia is on the order of 10s-100s females, although quantitative surveys have not been carried out (Limpus and Limpus 2003). A small portion of the loggerhead turtles foraging in eastern Australia migrate to breed in New Caledonia.

Australia

Until recently, the largest breeding rookeries at a global scale occurred in the eastern portion of Australia (Limpus 1985). Foraging areas spread over a 2,600km radius throughout eastern and northern Australia, Eastern Indonesia, Papua New Guinea, Solomon Islands, and New Caledonia (Limpus and Limpus 2003). However, there have been substantial declines in annual number of nesting females at all sites; the number has now fallen to less than 500 (Figure 6) from the 1977 value of about 3,500 reported by Limpus and Reimer (1994), an alarming decline of over 85% in just one generation (Figure 6). Recently, juvenile loggerheads have been found foraging in the southeast Pacific off the coast of Peru and Chile that are of Australian stock origin, suggesting that this stock is distributed across the entire southern Pacific Ocean (Dutton, in prep; see also Donoso et al. 2000 and Alfaro-Shigueto et al. in press), and is impacted by high seas fisheries operating in this region.

The Olive Ridley

The olive ridley is the smallest of the marine turtles, with CCL lengths of 60-70 cm and weights of less than 50 kg. It is distributed throughout the tropics, primarily in the northern hemisphere within the 20°C isotherms (Márquez 1990), although it is also common off the coast of ecuador and Peru, and has been found as far south as Chile (Donoso et al. 2000). Olive ridleys, like leatherbacks, lead a primarily pelagic existence, however, they also forage in nearshore benthic habitats. It is probably the most abundant of the sea turtles and can been found in large aggregations in open ocean areas of the eastern Pacific. It is a facultative carnivore and can switch from one food type to another, e.g., bottom dwelling and water-column crustaceans, mollusks, fish, and salps, as it moves between habitats (Kopitsky et al. 2002).

Olive ridleys have been exploited extensively for food and leather for centuries by local communities. Additionally, widespread egg harvest (both legal and illegal) continues.

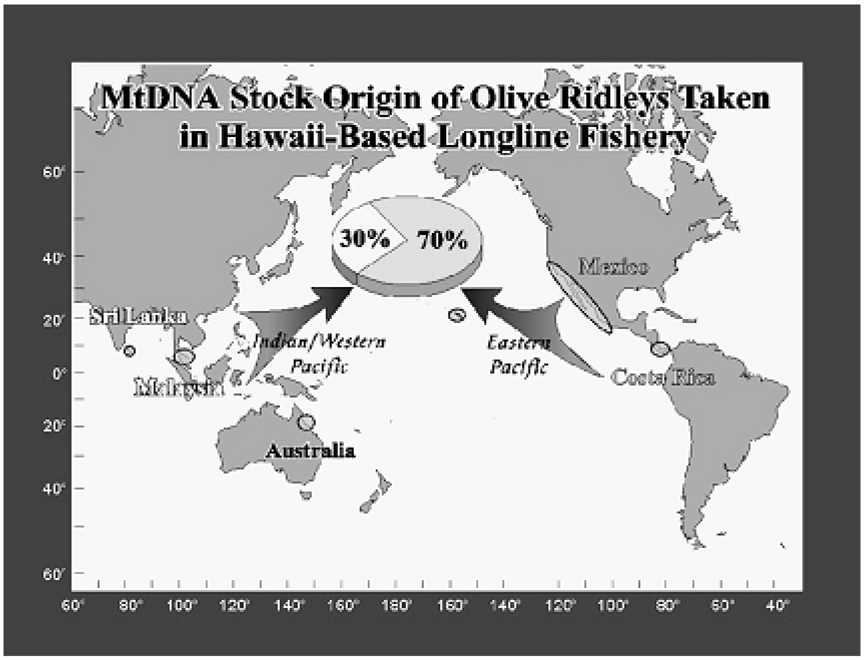

Figure 7. Stock composition of Olive ridleys in the North Pacific based on mtDNA sequence data from turtles encountered in the Hawaii-based longline fishery (Dutton, unpublished). Western Pacific nesting stocks are distinguishable from E Pacific stocks based on baseline data from Briseño-Dueñas (1998), and Bowen et al. (1998).

Major nesting areas occur throughout the eastern Pacific, from Baja California (Mexico) in the North to Panama in the South (Márquez 1990). Olive ridleys exhibit mass nestings, known as "arribadas", where tens of thousands of females come ashore to lay eggs on a single beach over a period of 2-3 days. In the western Pacific, arribadas have not been observed, but low density rookeries (<100 females/year) are scattered throughout Australia, Malaysia, and Indonesia (Figure 7).

The waters off southern Baja California in Mexico are an important developmental habitat used by early life-stages. Information on movement by adults has been gathered from flipper tagging studies and satellite telemetry. Work in Mexico illustrated extensive movements from continental nesting beaches northwards to coastal and oceanic waters off Baja California, as well as southwards as far as Central America, Colombia, and Ecuador (Márquez et al. 1976). Post-nesting olive ridleys from Costa Rica have been recovered or tracked as far south as Peru, as far north as Oaxaca in Mexico, and as far offshore as 3,000 km out into the Central Pacific (Plotkin et al. 1993; see also Parker et al. in press). In the eastern Pacific, they are often found associated with flotsam at current fronts (Arenas and Hall 1992) and make up the majority of sea turtle sightings by species (Pitman).

Genetic studies using mtDNA sequences can distinguish western and eastern Pacific stocks (Bowen et al. 1998; Briseño-Dueñas 1998), and the foraging animals encountered in the North Pacific come from both sides of the Pacifc (Figure 7). In the southeastern Pacific, olive ridleys come primarily from the eastern nesting stocks (Dutton, unpublished).

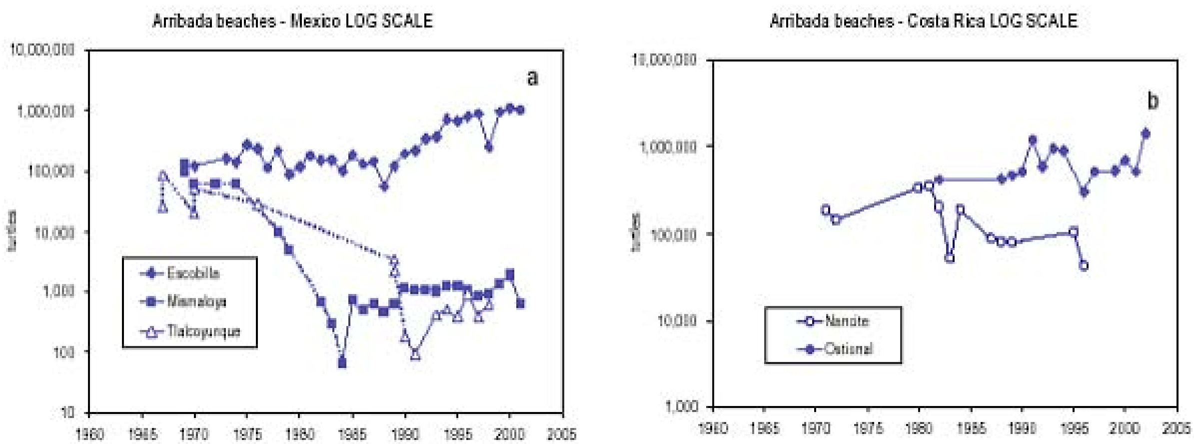

Figure 8. Long-term changes in annual nesting of Olive ridelys at (a) three arribada beaches in Pacific Mexico (Brise–o-Due–as and Abreu-Groboois 1994; M‡rquez et al. 1998; Pe–aflores-Salazar et al. 2001); and (b) two arribada beaches in Costa Rica (from Valverde et al. 1998) and Ostional (unpub. data from G. Chaves-Proyecto de monitoreo de la tortuga lora en el RNVS Ostional, Costa Rica. Escuela de Biolog'a, Universidad de Costa Rica). Note the Log scale on the Y axis (Graphs from A. Abreu-Grobois).

Abundance and population trends

Olive ridleys are the most abundant sea turtle in the Pacific, with large nesting populations occurring in Mexico and Costa Rica in the eastern Pacific (Figure 7). Intense harvest of adults and juveniles in fisheries in Mexico and Ecuador during the 1960s and 1970s caused dramatic declines, and in some cases collapse of nesting populations in Mexico. In 1990, Mexico implemented a total ban on the exploitation and commerce of all sea turtle species or products and since then nesting stocks have recovered dramatically (Figure 8). Although the former arribada rookeries have not recovered to historical abundances, the Escobilla colony has grown more than five-fold, from around 200,000 nests/year in the 1970s to over one million after the year 2000 (Peñaflores-Salazar et al. 2001; Figure 8). Despite this, nesting remains well below estimated historic levels, and there is concern that some of the populations that collapsed are still not showing signs of recovery. In Central America, trends are variable. While the arribada rookery at Ostional shows no evidence of decline in spite of the on-going egg harvest and, in fact, appears to be increasing (Chaves 2002), the Nancite colony appears to be declining (Valverde et al. 1998; Figure 8). Other arribada rookeries in the area include two in

Nicaragua (La Flor and Chacocente) and one in Panama (Isla Cañas) with densities up to 20,000 nests/year, both of which appear to be stable (Chacón and Arauz 2001).

There is little information on the Australian populations of the olive ridley. They use feeding grounds in Queensland, the Northern Territory, and Western Australia and breed at beaches in the Gulf of Carpentaria (Queensland) and the Arafura Sea (Northern Territory). In other areas of the western Pacific, quantitative information is also scarce. Trends from populations where information is available are very variable. In Terengganu, Malaysia, for example, where turtle meat is not permitted due to religious reasons, but egg harvest has been excessive for many decades, olive ridley abundance has collapsed.

Acknowledgments

I am grateful to Alberto Abreu-Grobois for his help in compiling backgound information and graphs, as well as Denise Parker, and to Colin Limpus for their input.

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Questions and Discussion

Comment: The story is a bit different for the Atlantic than the Pacific in terms of life cycle and demography. The presentation was a bit focused on the Pacific and the commenter suggested including additional info on status of turtles in the Atlantic and Indian Oceans as well as the Mediterranean Sea in the Workshop Proceedings.

Response: Dr. Dutton expanded on the status of turtles in the Atlantic and Indian Oceans. Currently, there are no good estimates on population status of olive ridleys, Kemp's ridleys are recovering, loggerhead status depends on individual sub-populations, and status of leatherbacks is unknown. The situation in the Atlantic is generally not as bad as the Pacific.

GLOBAL OVERVIEW OF INCIDENTAL CAPTURE OF MARINE TURTLES IN LONGLINE FISHERIES

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Introduction

As part of a larger project investigating the impact of pelagic longline fisheries on vulnerable pelagic species, we focused our efforts on estimating loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) bycatch from pelagic longline fisheries worldwide. Pelagic longlines are used to catch tuna (*Thunnus obesus*, *T. alalunga*, *T. albacares*, *T. albacares*) and swordfish (*Xiphus gladius*) around the world, with fishing effort extending across the Pacific, Atlantic, and Indian Oceans. Our objective for this preliminary analysis was to generate a minimum estimate of bycatch for loggerhead and leatherback turtles based on the best-available data. This minimum estimate brackets the lowest estimate of turtles taken annually in global ocean basins. Since presenting these preliminary results at the Workshop, we have completed our analyses of total number of turtles taken worldwide, and have focused particular attention on annual bycatch probabilities and post-interaction mortality for loggerheads and leatherbacks in the Pacific (Lewison et al. under review).

Methods

We took a methodological approach that utilized all available fishing effort and bycatch data. Our analysis relied on first identifying the number of hooks deployed by pelagic fishing nations, and then overlaying this effort information with the bycatch data to which we had access.

Calculating longline effort

We used three primary public domain data sources: ICCAT (International Commission for the Conservation of Atlantic Tunas) for the Atlantic, IOTC (Indian Ocean Tuna Commission) for the Indian, and the SPC (Secretariat for the Pacific Community) Oceanic Fisheries Programme for the Pacific. Data from the Pacific and Indian Oceans were provided in numbers of hooks set per area (ranging from 1°x1° to 20° x20° of latitude and longitude) per month or quarter. For the Atlantic Ocean, however, ICCAT released data in several forms. Some ICCAT member nations report fishing locations, effort, and catch - information we then used to calculate catch per unit effort (CPUE). These best (most complete) data tier nations included Brazil, Taiwan, China, Spain, Greece, Iceland, Japan, Korea, Mexico, Namibia, Panama, South Africa, and the U.S., and represented 69%

of the Atlantic data. Approximately 2% of the Atlantic data included reported fishing locations and catch in metric tons or number of fish landed. For these countries (Azores, several Spanish records, Portugal, Philippines, and South Africa), we converted reported catches into effort (number of hooks) by calculating the weighted average of reported CPUE from the best tier countries in the same 5°x5° grid cell. If no CPUE was reported for the grid cell, we used the weighted average of surrounding grid cells. The spatially explicit CPUE was then used to convert the reported catch to effort. The worst tier of Atlantic data included all other countries that were known to have caught more than 100 MT of tuna or swordfish, but did not report catch or effort (Algeria, Belize, Croatia, Cyprus, Equatorial Guinea, Italy, Madras, Honduras, Trinidad, Uruguay, Libya, and Morocco). For this data tier (28% of data), we used fishing locations from a 1997 CATDIS ICCAT database, and rescaled the 1997 catch per grid cell to reflect 2000 total reported catch levels. This catch was then converted to effort (hooks) using the spatially-explicit CPUE as described above. Previous research revealed that sets that target swordfish have turtle bycatch rates many times higher bycatch rates than tuna sets. To maintain this distinction, fishing effort was categorized into two target categories (tuna or swordfish). If target was not reported, we defined the target as the fish species with the largest catch.

Compiling bycatch data

Bycatch rates were taken from all available sources, including published research and in-country reports by regional fisheries management organizations or conservation organizations. To account for temporal variation in bycatch, we divided all observed bycatch by all observed effort to minimize the effect of any one bycatch event for grid cells where multiple data records were available. Bycatch rates were taken from raw observer data, observer data summaries, and bycatch assessments from other methods, e.g., questionnaires. For this analysis, we had bycatch information from 13 countries (see Figure 1).

Estimating bycatch

We overlaid our target-specific fishing effort with bycatch rates to generate our minimum bycatch estimate. To generate this minimum estimate, we assumed that turtle bycatch only occurred where it was observed and recorded; this includes records of zero bycatch. Under this assumption, any fishing effort in a grid cell without observer coverage is calculated to have zero bycatch. Data were stratified by species (loggerhead or leatherback), by target (swordfish or tuna), by season (quarterly), and by location (5° x5° grid cell). To account for spatial and temporal variation in turtle distribution in time and space and to avoid extrapolating beyond the limits of the data, bycatch data were only applied to fishing effort when it overlapped in target, space, and time. This means that if a bycatch rate was reported for Lat 40N and Long 70W, it could only be applied to fishing effort at that location. Likewise, if a bycatch rate was reported for quarter 4 (all effort was divided into 3 month quarters), that rate could only be applied to fishing effort in quarter 4. Swordfish bycatch rates were applied to swordfish-targeted effort only, and tuna bycatch rates were applied to tuna-targeted effort only.

Results

In 2000, pelagic longline fleets from 40 nations reported setting approximately 1.45 billion hooks targeting tuna and swordfish (Figure 2). Over half (52%) of the total fishing effort occurred in the Pacific Ocean (the largest by area), while the remaining effort was in the Atlantic (37%) and the Indian Ocean (11%). Six times more fishing effort targeted tunas (1.3 billion hooks) than swordfish (200 million hooks).

Our global minimum bycatch estimate is based on the number of hooks that overlapped (in space and time) with all accessible bycatch data (Figure 3). This estimate is the minimum number of turtles hooked or entangled by pelagic longlines per year. This estimate does not represent bycatch mortality. The specific calculations of this estimate are shown in Table 1. Our calculations suggest that, at minimum, approximately 55,000 loggerheads and 7,400 leatherbacks are caught as bycatch by pelagic longlines each year (Figure 4). The percentage of hooks included in the minimum estimate is the ratio of the number of hooks for which bycatch information was available to total hooks. These percentages clearly illustrate that the bycatch estimates we have generated are minima; our analyses accounted for less than 25% of total pelagic longline effort for both species. Because there are no bycatch data available for the Indian Ocean, we were not able to generate bycatch estimates for this basin.

In a preliminary attempt to extrapolate the number of turtles that were caught on all hooks, we scaled the minimum estimates up by the percent of hooks not included in the analysis (76% for loggerheads and 81% for leatherbacks). This extrapolation yielded similar results to another method of taking an average basin-wide bycatch rate and multiplying it by the basin effort. Both extrapolations suggest that approximately 230,000 loggerheads and 50,000 leatherbacks are incidentally caught annually by pelagic longlines worldwide.

Discussion

These results are preliminary and do not represent the final findings of this research. However, based on the data available at the time these analyses were completed, the minimum estimates represent our best attempt to characterize a lower limit of loggerhead and leatherback bycatch from pelagic longline fisheries. It is important to note that the extrapolated figures do not represent upper limits or confidence intervals. Since the Workshop in February, we have completed these analyses, and hope to release our findings in a peer-reviewed manuscript in the upcoming months.

Given the nature of the data, there are important caveats to this analysis. Of necessity, our analysis relies on reported fishing effort, catch, and bycatch rates from nations who are member states in the international fishing commissions. Thus, it is subject to error from misreported catch or effort, limited observer coverage, inaccurate spatial locations, or misinterpretation of fishing targets. A significant amount of reported fishing effort could not be included in our bycatch estimates due to unreported catch, i.e., ~77 million hooks set by the Chinese fleet with no clear target species. We were not able include fishing activities by all illegal, unregulated, and unreported (IUU) vessels, although we included some of this effort in the Atlantic based on adjusted IUU landings estimates completed by ICCAT. These caveats suggest that our minimum estimate is a conservative underestimate of the number of loggerheads and leatherbacks that are likely to be taken by pelagic longline fisheries.

The global nature of this conservation issue necessitates multinational management action and cooperation. At the time this preliminary analysis was completed, we knew of several other datasets that had not been published (Figure 5). Cooperation among scientists involved in bycatch research is essential to accurately evaluate the extent and impact of turtle bycatch from pelagic longlines. The United States has implemented both temporary and permanent fishery closures to reduce turtle bycatch and protect turtle populations. However, the relatively small contribution by the U.S. fleet to global pelagic longline fisheries (about 2% of worldwide landings) and the basin-wide distributions of both pelagic longline effort and sea turtles suggest that effective protection for loggerheads and leatherbacks will require coordinated international action. Multinational efforts are needed immediately to continue to develop and implement mitigation measures that can reduce or eliminate turtle bycatch across fleets.

Table 1. Minimum bycatch estimate calculations.

	# of turtles hooked (rounded to significant digits)	# of hooks included in estimate	# of total pelagic longline hooks/year	% of hooks in estimate
Loggerheads	54,000	301,200,156	1,450,094,484	24%
Leatherbacks	7,000	269,078,694		19%

Figure 1. Bycatch data for loggerheads and leatherbacks available for this analysis.

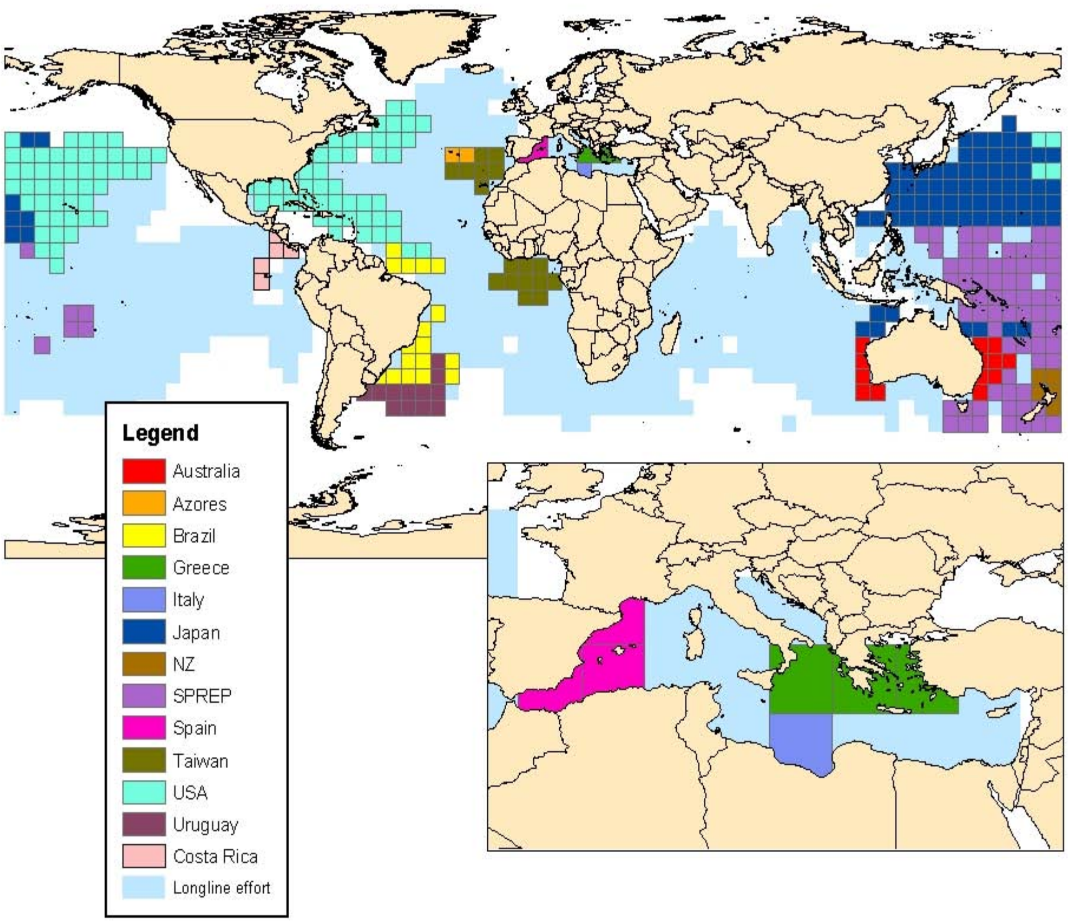


Figure 2. Reported pelagic longline fishing effort worldwide (tuna and swordfish effort combined).

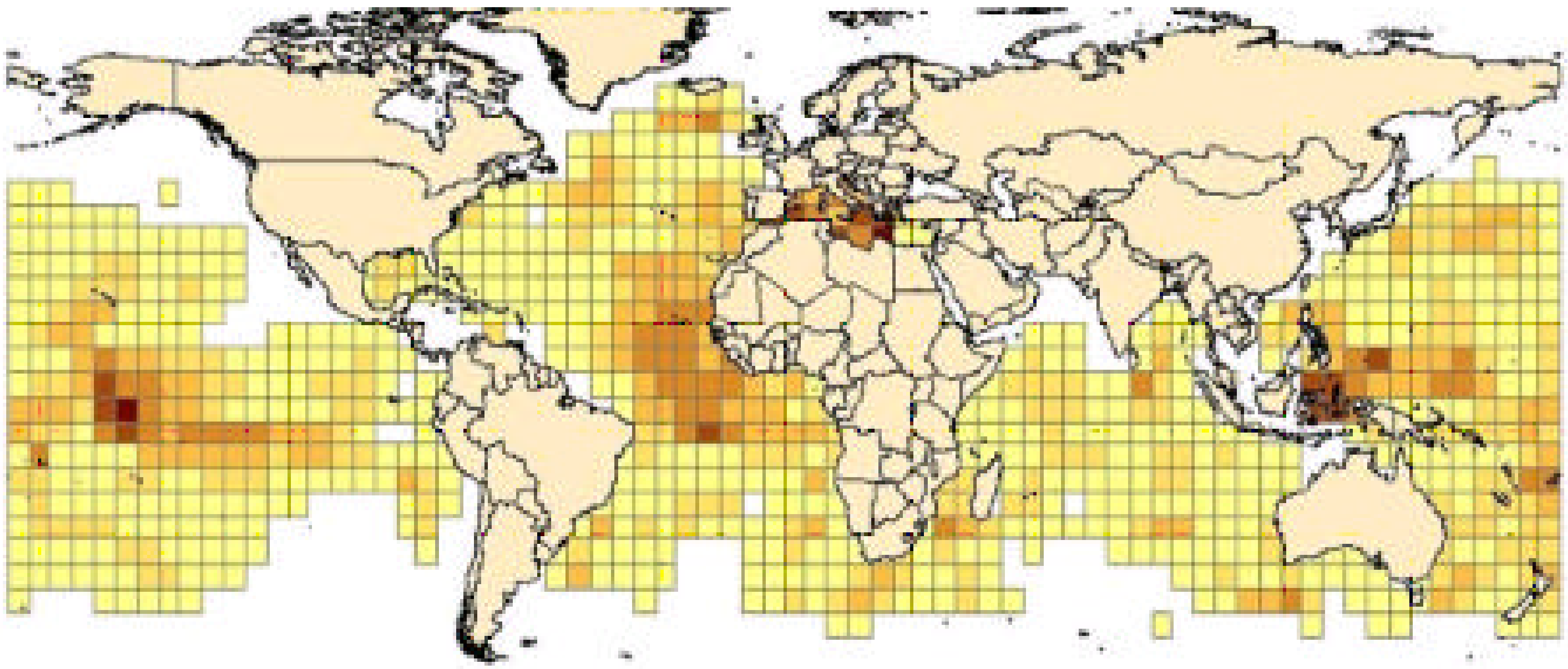


Figure 3. Overlap of bycatch and effort data.

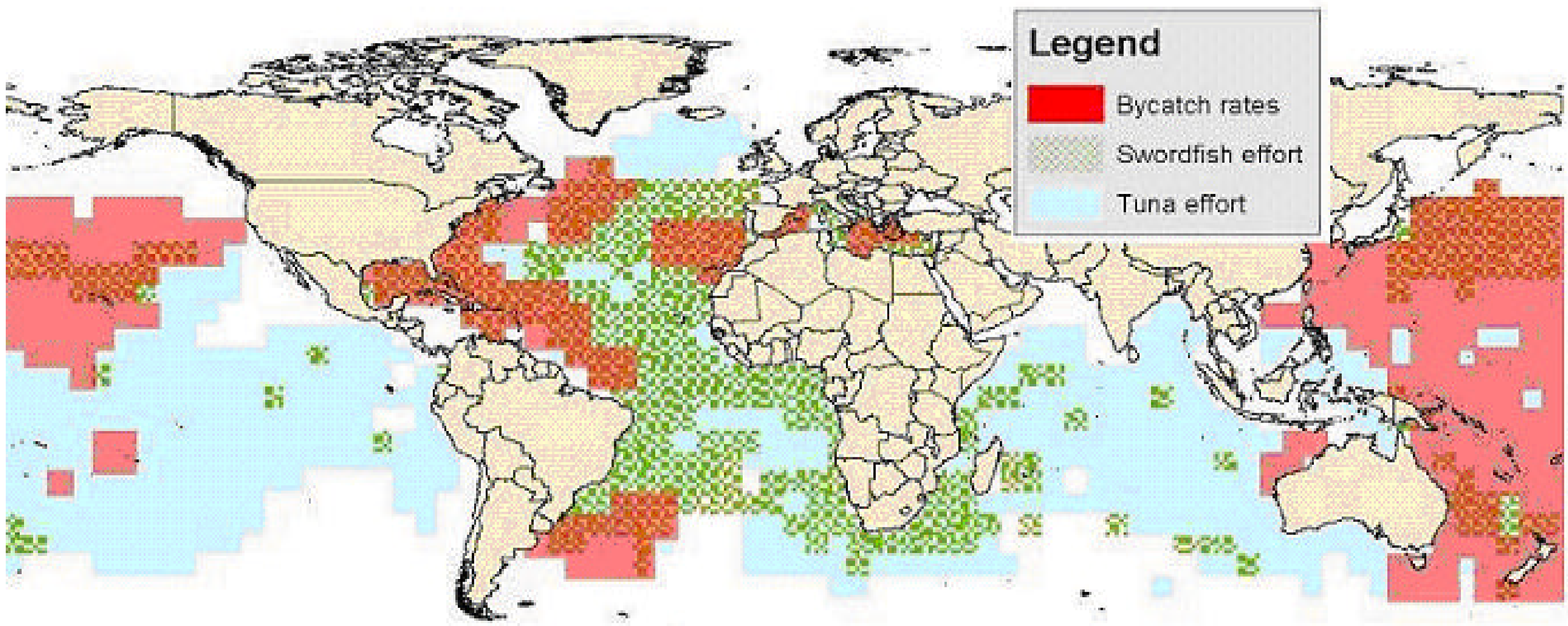


Figure 4. Minimum bycatch estimates for loggerheads (in green) and leatherbacks (in purple). The percent of the basin-wide fishing effort that could be included in this minimum (determined by amount of bycatch data) is shown in parentheses.

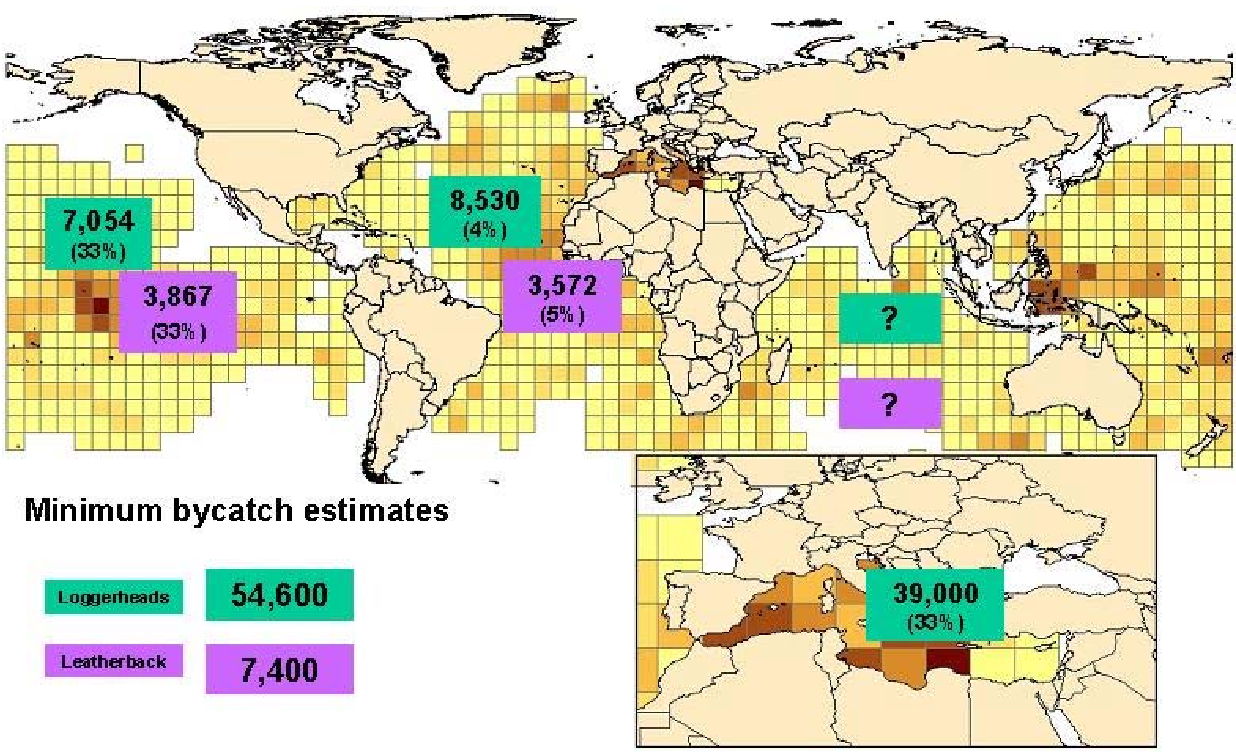
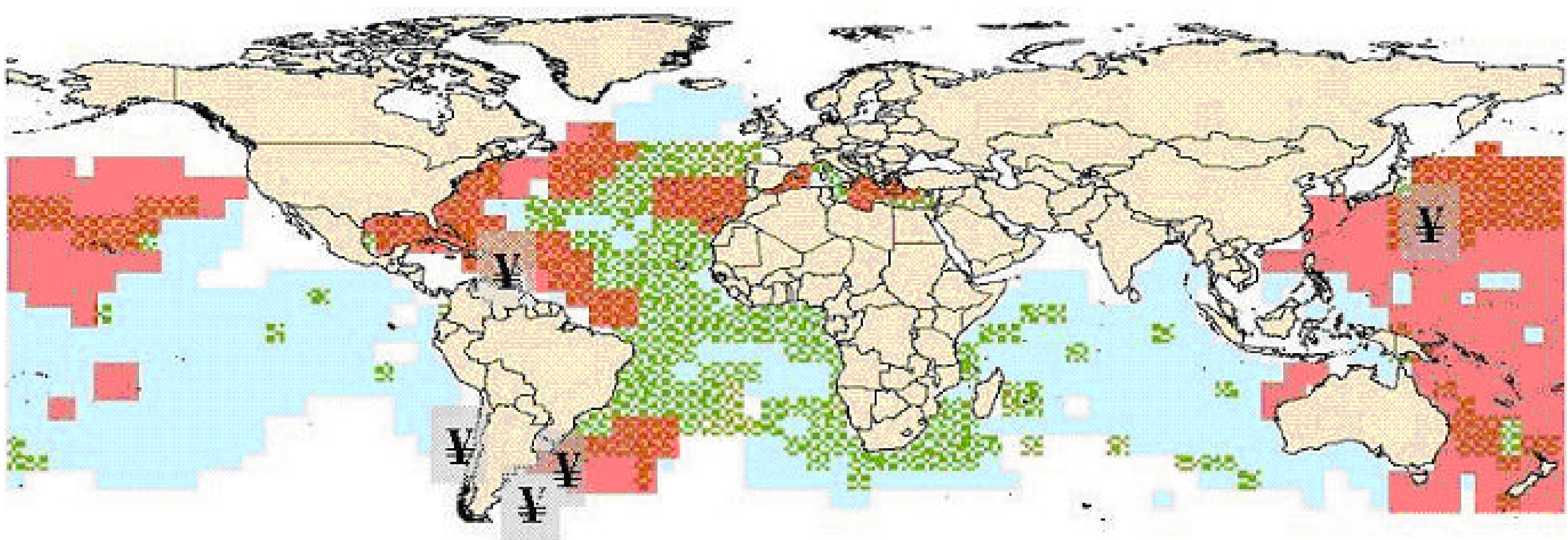


Figure 5. Areas where bycatch data have been collected, but have not been made available. Areas with unreleased data shown with symbols (¥).



PLENARY MODERATED DISCUSSION

Session: Overview of Marine Turtles and Longline Fishing

***Life History and Population Status of Sea Turtles in the Pacific*:**
A participant asked for clarification of leatherback status in Papua New Guinea. Those turtles that nest in Papua New Guinea seem to be moving north, directly though longlining grounds. Another participant responded that leatherback status is very unclear. There are still high numbers of adults but population trends are unavailable. Participant noted that while these turtles may be impacted by longlines and threats on the nesting beach, they might not be threatened by coastal gillnets. There are exemplary case studies, such as Malaysia where there has been 100% egg harvest for 50 years. If adults are still surviving they will keep nesting. However, the population decline from 50 years of egg harvest will take a long time to be reflected in the number of nesting females, due to the length of time it takes to reach maturity. Participants further explained that we need to look at the historical context of populations and understand what is happening on the nesting beach and how that is converging with fishing interactions. It takes many years for conservation measures on nesting beaches to reflect on nesting numbers. If a population is already depressed, even low levels of mortality from longlines can have large impacts. The threat from longline fishing is constant and a small population cannot sustain even low levels of mortality in the long-term. Another participant noted that if all other threats are mitigated, turtles may be able to sustain a low level of mortality at some point, but does this equal recovery?

***Global Overview of Turtle Bycatch*:**
Participants noted that this type of exercise is highly useful and making the process transparent to everyone is extremely important. Another participant noted that the Mediterranean is a small system with extremely high bycatch rates. The estimates of 36-60,000 were for the central area only; there was concern that bycatch in the eastern Mediterranean is not reflected in these estimates. Dr. Lewison explained that data from Algeria, Libya, and Cyprus were included in the database, but Syria, Turkey, and others were not. This concerned participants because most nesting areas are adjacent to the eastern Mediterranean. One participant questioned whether the 1000 capture estimate given for leatherbacks in the Mediterranean was too high since not many leatherbacks are sighted there.

A participant noted that bycatch in the Pacific was estimated as half that of the Atlantic and suggested examining density differences between ocean basins. Participants inquired whether 95% confidence intervals could be placed around bycatch estimates. Dr. Lewison explained that confidence intervals cannot be applied because some of the data used are summaries and not actual raw data points. She and her co-authors are still discussing the best way to approach this issue.

Participants commented that in the Pacific, the focus has been on leatherbacks rather than loggerheads. However, loggerhead nesting in the Pacific is extremely low, lower overall than leatherbacks, and this cannot be overlooked in the face of leatherback declines.

Several participants inquired whether these data allow for mortality estimates. The data presented were interaction estimates as there was not enough information to estimate mortality. There is a broad range of mortality estimates, size estimates, etc. within the data. They were also unable to determine estimates of population sizes to establish the context of these interactions. One participant reiterated that point, noting that time series models of abundance are necessary to incorporate life stage time lags.

Participants suggested that it would be helpful to understand the quality of the data, in other words, detail if data were Tier 1, 2, or 3. Participants also wondered if the data would allow for breaking up into subsets and explored in regard to seasonal and temporal changes. Dr. Lewison explained that data used were compilations of many data sets, some were summaries of data sets. Therefore, these summaries are not useful for that type of detailed analysis. That analysis might be possible if all the existing data were available. Participants further inquired whether multiple years of data are contained within a single cell, i.e., if it was possible to adjust bycatch rates for a particular cell over time in order to develop a time series. Dr. Lewison responded that cells that contain U.S. data were compiled for 5-6 years, but all other cells were for shorter time frames. Furthermore, effort data were compiled from 1999-2000 and bycatch data were from any point within the past 10 years, depending on availability. The researchers noted that while bycatch rates may change over time, they could not match up bycatch rates and effort for particular years, as that information does not exist.

Dr. Lewison noted that while pooling data, they did not discern between baiting techniques. Participants inquired whether data were separated based on target species, such as swordfish and tuna. Dr. Lewison explained that tuna and swordfish estimates were always considered and mapped separately.

Participants questioned whether the same methodology utilized to estimate turtle takes would be used to estimate sea bird bycatch. Dr. Lewison noted that there are more data of better quality available on sea birds and that analysis is likely to be more sophisticated, but the concept is essentially the same.

One participant noted that it might be useful to examine relative efficiency of fleets, assuming they will be different across distant water fleets. The participant recommended analyzing by target catch and extrapolating to turtle bycatch. Dr. Lewison noted that while they have explored this, the analysis is based on a basin wide mean of means. They did assume that some countries would be more efficient at minimizing interactions. Also, there were not enough data to tease out tuna species, such as albacore and yellowfin, and determine differences in bycatch rates depending on target.

Participants questioned the lack of data for the Indian Ocean. Several participants noted they were unaware of existing data on turtle bycatch, while some offered to look into it. One participant noted that the Indian Ocean differs from the Atlantic and Pacific in that most of the tuna catch is composed of bluefin tuna taken in the upper latitudes where turtles may be less prevalent. Therefore, bycatch analysis should consider latitudinal bands in the extrapolation for basin wide estimates.

One participant inquired whether multiple captures/interactions were incorporated into the analysis. This participant noted that, based on observer data, multiple captures were common in the Northeast Distant Area of the Atlantic, but were infrequent in the Pacific. Another participant countered that recaptures are not that common in the Atlantic. However, the number of hooks in the Mediterranean is equivalent to the number of hooks in the entire Atlantic, therefore, the chance of recapture in the Mediterranean seems to be much higher than the Atlantic.

A participant asked what the particular issues were with accessing observer data. There are some data sets from observer programs that have 100% coverage (e.g., Chile) and then there are data sets which have been collected haphazardly and have not been published or made available. The participant further inquired whether these data were languishing and just unavailable or if countries are leery of providing data because it might economically affect fisheries. Dr. Lewison explained that there are two issues: 1) Mining existing data sets to elucidate useful information; and 2) Designing a long-term strategy for obtaining necessary data. One participant noted that in South America, data do exist; at issue is a lack of staff to clean up and analyze data. Other participants inquired whether the PEW project had funds to contribute to these efforts by providing contracts, as opposed to just simply utilizing data. Unfortunately, the PEW project does not have the capacity to facilitate contracts and such. However, they are willing to assist countries and groups with data analysis. Dr. Lewison iterated that the project used data as conservatively as they felt prudent. They welcome corrections and additions if others have pertinent information.

One participant found the bycatch estimates in the Mediterranean and Atlantic astounding, e.g., 100,000 turtles caught. The size classes of turtles encountered in both areas are similar. The participant inquired whether there was a way to distinguish between the eastern and western Mediterranean. Dr. Lewison explained that bycatch in the western Mediterranean was estimated as 30,000 of the 100,000 turtles.

Participants noted that it would be ideal to use direct mortality in the model as opposed to estimated mortality.

Another participant suggested identifying areas and time series that are important to get the overall picture of bycatch, since it is not so helpful to have random data points spanning 40 years. He specifically suggested a jack knife approach to determine whether certain areas or periods are more influential.

One participant reminded the group of the tremendous conservation effort on nesting beaches for western Atlantic populations of loggerheads and leatherbacks. Similarly, conservation on nesting beaches in the eastern Pacific is also intense. Although there are other fishery impacts, pelagic longlining is the most important factor to address in preventing extirpation of Pacific loggerheads and leatherbacks.

BYCATCH REDUCTION RESEARCH

ORAL PRESENTATIONS
AND
PLENARY DISCUSSION

EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS TO EVALUATE SEA TURTLE MITIGATION MEASURES IN THE PELAGIC LONGLINE FISHERY

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Abstract [The authors declined to provide a full paper for inclusion in the Proceedings. An internet link to the project report is provided on the following page.]

NOAA Fisheries in cooperation with the U.S. pelagic longline fishery implemented a three year research program in the Western Atlantic Ocean to develop and evaluate sea turtle mitigation measures. Five potential mitigation techniques were evaluated during 687 research sets in 2001 and 2002. Data were collected to evaluate the effectiveness of the mitigation measures and to investigate variables that effect sea turtle interaction rates with pelagic longline gear. A significant reduction in loggerhead catch may be achieved by reducing daylight soak time. 18/0 circle hooks and mackerel bait were found to significantly reduce both loggerhead and leatherback sea turtle interactions when compared with industry standard J hooks and squid bait. Also, 18/0 circle hooks significantly reduced the rate of hook ingestion by the loggerheads, reducing the post-hooking mortality associated with the interactions. The combination of 18/0 circle hooks and mackerel bait was found to be the most efficient mitigation measure for both loggerhead and leatherback turtles. Mackerel bait was found to be more efficient for swordfish than squid bait and circle hooks were more efficient for tuna than J hooks.

A full report of this research is available online at:
http://www.mslabs.noaa.gov/mslabs/docs/watson2pdf.

Questions and Discussion

Question: Please elaborate on the results regarding types of interactions with threaded versus single baited hooks.

Response: For loggerheads, captive experiments showed that turtles gulped and swallowed 9/0 J hooks baited with squid, but tended to bite mackerel rather than attempt to swallow it whole. As far as threaded versus single mackerel baited hooks, turtles can more easily pull bait off a single baited hook than a threaded bait.

Question: What is the difference in cost for mackerel and squid?

Response: Mackerel is generally cheaper than squid.

Question: How were experiments on feeding behavior conducted?

Response: Feeding behavior studies were conducted using captive reared loggerhead turtles in a laboratory environment. Turtles were presented hooks of different types and sizes baited with either squid or mackerel bait. The hook points and barbs were removed and the blunt end of the hook remaining was covered with heat shrink tubing to prevent injury to the turtles. The feeding behavior of the turtles was observed and video taped for analysis. The objective of the experiments was to determine if hook size affected swallowing of hooks by turtles of the size encountered by pelagic longlines.

Question/Comment: One participant noted that artisanal fisheries use smaller hooks and inquired whether switching to circle hooks would have a significant impact.

Response: Data indicate that circle hooks (with no or minimum offset) tend to hook turtles in the mouth rather than internally, which could greatly increase post-release mortality. Therefore, circle hooks would have an impact in artisanal fisheries especially if the gear can be removed from the turtle. Circle hooks have been shown to be effective hooks for many target species. Fishers should use the largest circle hook possible that maintains acceptable target catch rates.

HAWAII FISHING EXPERIMENTS TO REDUCE PELAGIC LONGLINE BYCATCH OF SEA TURTLES

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Objective of Research

In 2002, the National Marine Fisheries Service (NMFS) Honolulu Laboratory conducted experiments using longline fishing methods designed to reduce sea turtle bycatch and mortality. The objective was to develop economically viable and environmentally sound longline fishing methods that will be more selective for target species (swordfish and tuna) while reducing or eliminating sea turtle bycatch. The long-term goal is to implement such fishing methods globally. This research was designed to complement similar research being conducted in the Atlantic Ocean, although longline fishing strategies and tactics differ between the two oceans. The study involved experiments with modified fishing gear and fishing operations conducted at sea with contracted fishing vessels.

The original plan for this research was two-fold: (1) large-scale testing of minor, economical gear modifications to determine effects on turtle bycatch and (2) small-scale testing of major, expensive gear modifications to determine economic viability. In January 2002, the NMFS Office of Protected Resources issued a Scientific Research Permit (Permit 1303) under Section 10 of the Endangered Species Act (ESA), authorizing part of this research (Phase I). The large-scale testing was covered by Permit 1303 but was postponed until after 2002 (Phase II). In June 2002, the Ocean Conservancy, Turtle Island Restoration Network, and Center for Biological Diversity filed a complaint with the U.S. District Court for the District of Hawaii against NMFS, the Department of Commerce, and the Secretary of Commerce challenging the permit, the Biological Opinion analyzing the experiment, and the National Environmental Policy Act (NEPA) analysis of the experiment. Ensuing litigation halted the research in 2002, and NMFS subsequently withdrew Permit 1303. After NMFS has completed an Environmental Impact Statement, a new permit may be issued for further research, which may include large-scale fishing experiments similar to those originally proposed.

Proposed Fishing Experiments in the Pacific

Fishing experiments were designed to test various gear modifications over three years using chartered longline fishing vessels to conduct research longline fishing operations. The largest effort was intended to test alterations to fishing gear and operations to reduce turtle bycatch based on analyses of observer records collected during 1994-99 and results from experiments conducted with captive sea turtles. Statistical analysis of five years of Hawaii longline fishery observer data showed that branch lines attached less than 40 fathoms from float lines catch the most turtles (Kleiber and Boggs 2000). Based on this finding, an experiment was designed to test the effectiveness of modifying longline fishing operations by attaching branch lines more than 40 fathoms from float lines. These experimental longline fishing operations also included blue-dyed bait as part of the treatment to be tested against a control, with normal fishing operations using natural squid bait. Strong evidence from studies with captive sea turtles shows that green and loggerhead sea turtles are attracted to natural squid bait, but when they are presented with a choice between blue-dyed squid bait and normal squid bait in controlled experiments, the turtles completely ignore the blue bait for nearly 10 days (Swimmer and Brill 2001; Swimmer et al. 2002).

The statistical design of the primary large-scale gear modification experiment called for 520 research longline sets per year with a similar number of sets serving as the control. This number of sets was designed to allow detection of a 50% reduction in sea turtle bycatch compared to the control sample. These experiments would have required about nine full-time longline fishing vessels per year, or a larger number of vessels fishing part time. The annual numbers of sea turtle 'takes' estimated for the testing of moved branch lines and blue bait would have been 87 turtles, including 31 mortalities. Estimated mortalities include immediate mortality plus estimated delayed mortality. It is assumed that 0.27 lightly hooked and 0.42 deeply hooked turtles suffer delayed mortality (following NMFS's official delayed mortality policy). The large-scale testing of modified fishing gear was postponed; however, several other experiments allowed by Permit 1303 were completed during Phase I in 2002. A maximum of five observed or delayed mortalities (4 loggerhead turtles and 1 leatherback turtle) were allowed by Permit 1303 in Phase I.

Fishing Experiments Authorized by Permit 1303

Permit 1303 allowed limited testing of stealth (camouflaged) swordfish and tuna longline fishing gear and deep daytime swordfish setting to evaluate whether modified gear would retain viable economic performance. If so, future testing to demonstrate turtle bycatch reduction will be proposed. This phased approach minimized impacts on sea turtles until major fishing modifications with potential for bycatch reduction are shown to be economically viable. Permit 1303 also allowed research using electronic hook timers and time depth recorders to document when and where turtle bycatch occurs during the sequence of longline deployment, information vital to the development of additional methods that may be tested and used to reduce sea turtle bycatch in pelagic longline fishing. In addition, we were allowed to test the effectiveness of large (18/0) circle hooks for catching target species. Circle hooks have been found to be less injurious to sea turtles, and testing these hooks was piggybacked on the same research sets used for the hook timer research. As a result, there was no separate take estimate for the circle hook tests, and the potential for injury to turtles taken in the hook timer experiments was reduced.

In 2002, 194 research longline sets were completed including 99 research sets made by three Hawaii longline fishing vessels on contract to NMFS to test deep daytime fishing for swordfish (33 sets), stealth swordfish longline fishing gear (33 sets), and controls (33 sets). Two other vessels made 95 research sets with hook timers and large circle hooks. Three sea turtles, all hooked in the mouth, were taken during the fishing experiments in the Pacific, and all were released alive. A leatherback, lightly hooked with a circle hook and a loggerhead turtle, deeply hooked with a "J" hook, were caught during hook timer experiments. One loggerhead turtle was lightly hooked with a "J" hook during control fishing conducted as part of the deep daytime and stealth experiments.

Results on Stealth (Camouflaged) and Deep Daytime Fishing Gear

In 2002, these gears were tested for viability in maintaining target species catch-per-unit-of-effort (CPUE) in swordfish-style (shallow set, nightime) fishing operations (Table 1). "Stealth" fishing gear was designed to reduce the visibility of longline gear to sea turtles. Target species CPUE was also tested for deep-set swordfish fishing. This method targets swordfish deep where they descend during the day using tuna-style numbers of branch lines between floats (Table 1) and swordfish-style bait and lightsticks in areas where near-surface nightime swordfish abundance is high. Statistical testing of differences in turtle take rates was not an objective and although a few takes were anticipated, none were required for the success of these initial experiments. Efforts to avoid taking turtles in the stealth and deep swordfish fishing tests included conducting these operations after the season of highest incidence of takes (e.g., after January-February).

The stealth and deep day swordfish experiments were designed to be conducted synoptically with three vessels: one conducting control operations to demonstrate high near-surface abundance of target species, another conducting stealth tests, and the third conducting deep daytime fishing for swordfish. Economizing on the control operations avoided turtle takes that might have occurred if a separate set of control operations were required for each method.

Dark blue-grey monofilament was used for main line, float lines, and branch lines. Battery powered, narrow-frequency, yellow light-emitting diode- (LED) based, down-welling (shaded on the upper half) light sticks were used on stealth gear and regular chemical light sticks were used on control gear. The shiny stainless-steel branch line and float line snaps were painted dull blue, and the squid bait was dyed blue as described in Boggs (2000).

Deep daytime fishing operations for swordfish used the same depth configuration as that of tuna gear. Target depth was achieved using a main line shooter, much longer main line, and more hooks between floats than with swordfish-style gear, while maintaining the standard swordfish-style number of branch lines per set (Table 1). Fishing depth was measured with time-depth recorders.

Experiments on tuna-style fishing gear were not initiated in 2002 because of a delayed start and coordination problems with separate contractors. Only one set of stealth gear was procured, and its first priority was to complete stealth experiments in swordfish-style fishing operations. The experiments began March 15, 2002. One fishing vessel (F/V) made normal night-time swordfish sets, another vessel made simultaneous stealth swordfish sets, and a third vessel worked 12 hours out of phase making deep daytime swordfish sets. These F/Vs fished within 30 nautical miles of each other for three trips, totaling 33 longline sets per vessel (99 sets total) and completed their contracted work at the end of May 2002 (Table 2).

Observers onboard each vessel monitored the fishing operations to ensure that each vessel followed research protocol and observed interactions with sea turtles and albatrosses. Conditions of Permit 1303 established by the U.S. Fish and Wildlife Service required extensive observation and data collection on seabird interactions that prohibited observers from conducting their normal fish data collection activities. Therefore, data on the catches of swordfish, tuna, and miscellaneous marketable species were monitored via vessel logbooks. Catch and revenue from the catch were also monitored at the fish auction in Honolulu (Table 3).

The stealth fishing gear caught significantly fewer swordfish than the control gear (pair-wise t-test, n=3 trips, $p<0.015$). Swordfish revenue by the stealth F/V was reduced by 30% compared with the performance of the control F/V. Overall revenue was reduced 39% from reduced catches of tunas and other species (% Loss, Table 3). Past catch rates of control and stealth fishing vessels were compared to determine if they performed equally when both F/V's used normal swordfish gear. Swordfish CPUE (fish per 1,000 hooks) during March-May of 1997-2001 were analyzed. The stealth vessel's past performance using normal gear averaged 9.4 swordfish per 1,000 hooks (n=123 sets) and the control vessel averaged 10.4 swordfish per 1,000 hooks (n=160 sets), a difference not statistically significant ($p>0.05$). In the experiments the stealth vessel averaged only 6.8 swordfish per 1,000 hooks (n=33 sets) but the control vessel averaged 12.2. The reduced performance by the stealth fishing vessel appears gear related and not an intrinsic difference in vessel performance.

Gear modification resulting in a 30% reduction in swordfish revenue may not be economically viable in a fishery such as the Hawaii fishery with a profit margin under 10%. However, performance at 70% of the nominal level in a first trial indicates considerable promise for the gear modification if fishing efficiency can be increased. One possibility would be to use another type or color of light stick instead of the yellow LED light sticks used in the Phase I swordfish stealth experiment. Yellow light sticks are the least preferred by fishermen, but the only two colors that had been investigated with captive turtles at the time of these tests were yellow and green. Turtles were attracted to green but not to pure yellow, but since then research with captive turtles has shown them to be attracted to a wider spectrum of colors including yellow. Future work may involve repeating the swordfish stealth experiment using a different type or color of light stick. The turtle catch rates assumed for Permit 1303 predict that 2.7 loggerheads and 0.5 leatherbacks would have been caught on the 33 stealth swordfish sets if the gear had no effect in reducing turtle bycatch. Since the stealth gear modifications did not result in any take and did show some promise of economic viability, it may be prudent to continue testing stealth gear modifications.

The deep daytime fishing trials for swordfish did not fare nearly as well as the stealth fishing. The catch of swordfish was 85% less than with the control gear (Table 3). The catch of tuna and other species, however, was not as reduced as the swordfish catch. In terms of weight (but not value) the catch of other species was about the same as in control fishing (1% difference). Overall revenue was reduced by 71% for deep daytime fishing.

Pressure data from a time-depth recorder (TDR) on the deep daytime main line (Figure 1) indicated pressures consistent with tuna-style fishing. Converting pressure to depth (Table 4) shows that the deep daytime sets averaged about 244 m, whereas control and stealth sets averaged about 19 m. The TDRs were attached to the middle of the sag in the main line between floats (typically the deepest part of the main line). The deepest hooks typically fish about 1 branch line length (ca. 17 m) deeper than the TDR, and the rest of the hooks typically fish between the TDR depth and the combined depth of float line and branch line (ca. 25 m). Hook depth also varies greatly due to bending of the main line by wind, current shear effects, and by caught fish pulling the line. The deep daytime gear fished deeper than average tuna gear, but probably not deep enough for swordfish; tracked swordfish swim at depths exceeding 400 m during the day. The deep daytime fishing vessel may have been setting only deep enough to occasionally encounter swordfish. The contract vessels have only recently learned to fish deep for tuna, and during the experiment we learned that they are not capable of retrieving gear set deeper than 300 m in the rough northern waters where swordfish occur.

No sea turtles were caught in the deep daytime fishing experiment, although catch of 0.5 olive ridley and 0.2 leatherback turtles were expected based on catch rates used in estimating takes for Permit 1303. Only one turtle was taken among the trio of fishing vessels conducting the control versus stealth and deep daytime fishing methods: a loggerhead taken by the control vessel. It may be prudent to continue testing deep daytime swordfish gear since it has not yet caught any turtles and because the ability to handle gear at greater set depths can be attained by contracting more experienced tuna longliners.

Phase I Results from Hook Timer Experiments with Piggyback Project on Circle Hooks

Two vessels conducted typical swordfish fishing operations with branch lines equipped with hook timers, beginning in April 2002. A total of 95 sets were made (Table 5) amounting to only about half of the effort planned (181 sets) for the first year. A single leatherback turtle capture provided the only hook timer data collected so far in the study. The hook timer indicated that the leatherback was hooked 35 minutes before being sighted on the line and 37 minutes before being brought alongside the vessel. The time of capture was 0738 HST, 1 hour after local sunrise at ca. latitude 29°N, longitude 174°W. The leatherback threw the hook by itself and escaped. One loggerhead was also captured, but the hook timer malfunctioned.

Approximately 20% of branch lines in the hook timer study were equipped with 18/0 circle hooks for comparison with the catch of target species by typical swordfish-style J hooks. Neither hook type was offset.[1] Effectiveness of circle hooks at catching target species was evaluated based on the ratio of swordfish and tuna caught on these hooks versus those caught on J hooks. The numbers of fish caught were adjusted based on the ratio of circle hooks to J hooks deployed on each fishing trip (Table 6) to produce a percentage (effectiveness) that represents the fraction caught by circle hooks in relation to the number caught on an equivalent number of J hooks. Over all seven trips by the two vessels, circle hooks were only 40% as effective as J hooks at catching swordfish, but were 94% as effective as J hooks at catching tuna, based on the numbers of fish on each hook type recorded by the observers (Table 6).

Effectiveness was also judged by weight and value of the target species catch at auction. Almost all of the fish caught were landed and sold at auction. The average weight and price of fish caught on circle and J hooks from each trip were used to convert the number of observed catches into weight and value of catches from each trip (Table 6). Based on weight, circle hooks were only 37% as effective as J hooks at catching swordfish, but were 89% as effective as J hooks at catching tuna. And based on value, circle hooks were only 33% as effective as J hooks at catching swordfish, and 82% as effective as J hooks at catching tuna (Table 6). All circle hook percentages for swordfish (based on number, weight, and value) were significantly lower than 100% ($n = 7$ trips, $p < 0.01$). Differences between effectiveness by number, weight, and value of fish were due to a smaller average size and price for fish caught on circle hooks, but only the difference in swordfish size was statistically significant ($n = 7$, $p < 0.05$). These results do not support the economic viability of using larger circle hooks to catch swordfish. Results from 2002 Atlantic experiments with circle hooks, along with mackerel bait, are more promising (see paper by Watson, this volume).

Differences Between Atlantic and Pacific Experiments with Moved Branch Lines

Fishing experiments conducted to evaluate longline fishing methods to reduce sea turtle bycatch in the Atlantic Ocean in 2001 tested moving branch lines located nearest to float lines to positions farther away from the float lines, as proposed for the Pacific experiments. However, because of differences in longline fishing gear configurations used in the two oceans, the branch lines were moved only 20 fathoms away from the float lines in the 2001 Atlantic experiments. The 2001 Atlantic experiments also tested the use of blue-dyed bait to reduce pelagic longline bycatch of sea turtles. Both gear modifications failed to reduce sea turtle bycatch in the northwest Atlantic (Watson 2002).

Examination of schematics portraying the arrangement and dimensions of longline gear in the Pacific and Atlantic experiments helps to explain why moving branch lines away from float lines to reduce sea turtle bycatch has not yet been adequately tested (Figure 2). The Pacific modification design removes the branch line adjacent to the float (Figure 1a) and moves it among the other deep hooks (Figure 1b) below the hypothesized turtle layer, out of the 40-fathom "attraction zone." Tracking of sea turtles indicates that they spend most of their time at depths less than 40 m (Polovina et al.

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[1] Offset hooks have the point bent to the side, out of alignment with the shank. Offset hooks are preferred by some fishermen who believe that the offset point is more likely to catch and hold swordfish.

2002). Atlantic fishermen fish within a different habitat and use shallower gear with fewer hooks between float lines (Figure 1c). The Atlantic gear modification moved the float line only 20 fathoms away from the adjacent hook by moving it 20 fathoms closer to the preceding hook (Figure 1d). Thus, the average distance from the float line to the nearest two branch lines remained unchanged. In the Atlantic experiment, more hooks ended up in the hypothesized 40-fathom attraction zone, and more hooks ended up in the shallow 40 m depth zone than in the control fishing mode.

Reasons for Proceeding with Fishing Experiments in the Pacific

Separate Pacific experiments are required because pelagic longline fishing strategies and tactics differ between the North Atlantic and North Pacific oceans. These differences in fishing strategies and tactics are related to fundamental differences in oceanic structure and ecology. The Atlantic fishery operates primarily at edges of the Gulf Stream in an ecosystem influenced by relatively near-shore environments and comparatively shallow habitats, whereas the North Pacific operates in two mid-ocean ecosystems that are markedly different from the Atlantic.

In the Atlantic, the swordfish fishery targets environmental features that occupy a relatively small geographic area, making the concentration of branch lines in the areas of these features important. In the "northeast distant" (NED) and mid-Atlantic bight (MAB) areas where most turtles are caught in the fishery (Hoey 2000), swordfish are often found in association with the shelf-break thermal front (Podesta et al. 1991). In these habitats, swordfish commonly spend the day on shallower banks, feeding on bottomfish (Scott and Tibbo 1968). Submarine canyons on the edge of the shelf are also good regions for swordfish catch, and fishermen often target these specific locations. (Carey and Robison 1981). In the NED, most turtle captures are associated with thermal fronts along the Grand Banks, especially in late summer and fall when warm-core Gulf Stream eddies bring water with temperatures higher than 20°C into the area (Hoey 2000).

In contrast, the Pacific fishery is not oriented to bathymetric features. In the Pacific Ocean, virtually no banks or shelves provide target habitats for swordfish fishing by the Hawaii-based fleet, which operates primarily over bottom depths of >4000 m (Bigelow et al., 1999). The closed swordfish fishery, once responsible for most of the longline turtle catch by Hawaii-based longliners, occurred primarily at the southern edge of the North Pacific Transition Zone (Bigelow et al. 1999; Roden 1991). The southern edge of the zone, called the subtropical frontal zone (STFZ), is characterized by salinity fronts throughout the year and by temperature gradients of about 3°C/100 km from late fall through early summer. The STFZ temperature gradients and frontal dynamics described by Roden (1991) are more diffuse and less dynamic than those in the Atlantic fishery (Podesta et al. 1993). Therefore, Pacific fishermen have increased the distance between branch lines to about 40 fathoms to explore a wider area per unit of fishing effort.

In the NED fishing grounds, where the Atlantic experiments were conducted, water temperatures are often too cold for loggerhead sea turtle habitat. Results of the Atlantic experiments indicate significant increases in turtle bycatch in portions of longline sets hauled in the afternoon (Watson 2002) perhaps reflecting a temperature-based increase in foraging activity due to afternoon warming of the sea surface. Loggerhead turtles are observed basking at the surface in the NED fishery. In the Pacific subtropical convergence zone fishery, turtles typically experience warmer temperatures and analyses of observer data indicate only a weak relationship between time of haulback and loggerhead turtle bycatch. One mitigation method tested in the Atlantic fishery in 2002 involved shortened soak time to reduce the amount of gear hauled in the afternoon. Evidence suggests this measure would not be very effective in the Pacific fishery.

The swordfish fishery in the North Atlantic occurs in waters of higher productivity compared to the North Pacific. The Atlantic and Pacific swordfish fisheries are concentrated at the junctures of two provinces in each ocean, as defined by primary productivity regimes (Longhurst et al. 1995). In the Pacific, the fishery is concentrated at the juncture between the North Pacific Subtropical Gyre (NPST) and the North Pacific Tropical Gyre (NPTG). In the Atlantic, the fishery is concentrated at the juncture between the Northwest Atlantic Continental Shelf (NWCS) and the Gulf Stream (GFST). Productivity is high in the NWCS, moderate in the GFST and NPST, and low in the NPTG. Comparing relative productivity (grams of carbon per meter squared per day) of these provinces indicates that the Atlantic NWCS is about 5 times that of the Pacific NPTG, and the Atlantic GFST is about 2 times that of the Pacific NPTG (Longhurst et al. 1995). Specifically, high production and turbidity in the NWCS result from oceanographic and topographic factors absent from the Pacific fishery ecosystem. These factors include, but are not limited to, coastal upwelling and algal blooms along the southwest coast of Nova Scotia, a consistent shelf break front that results from instability between shelf and slope water masses, and a shallow continental shelf that retains nutrients in the photic zone, thereby maintaining relatively high primary production with a concomitant decrease in water clarity.

In summary, the blue water of the Pacific fishery is less productive than the waters of the U.S. Atlantic fishery. The foraging ecology and behavior of loggerhead and leatherback turtles caught in the Pacific and Atlantic fisheries may also be different, and blue dye may better obscure the bait from a turtle's view in the Pacific. Furthermore, because turtles are less densely congregated in the Pacific fishery, any mitigation measure that makes bait less visible will likely have more impact. In the Atlantic, dense distribution of turtles may make them much more likely to encounter the gear either by smell or simply by chance.

Leatherback sea turtle bycatch on branch lines attached immediately adjacent to float lines (control) and 20 fathoms (branch line moved) from float lines significantly increased in the Atlantic NED experiments (Watson 2002). This finding strongly supports the need to conduct the 40-fathom moved branch line experiment designed for the deeper Pacific fishery. Scientists responsible for designing and analyzing both the Atlantic and Pacific turtle longline bycatch experiments met in Honolulu, Hawaii in September 2002 to review these results and recommend future work. The available information from (1) the Atlantic experiments, (2) analyses of Pacific observer data, (3) experiments with captive sea turtles, and (4) our understanding of ecosystem differences between the Atlantic and Pacific fisheries strongly support the completion of all experiments proposed for the Pacific.

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Questions and Discussion

Comment: One participant noted that Dr. Boggs gave the impression that gear configuration in the Atlantic is relatively static, however, this participant's observations suggest a wide range of variability in the Atlantic.

Response: Presenter agreed that gear configurations in the Atlantic are variable, although not as variable as the Pacific.

Question: Are the results of these experiments available in written form?

Response: The 2001 results from John Watson's work and the final report from Dr. Boggs's work are available, but 2002 results from Watson are still being analyzed.

Question: What kind of light was used?

Response: Chemical light sticks

Table 1. Average of fishing gear parameters for the Hawaii-based longline fishery using two styles of fishing - swordfish-style and tuna-style fishing. Control fishing operations in the experiments strictly adhered to the parameters given below for swordfish-style fishing. The deep daytime swordfish fishing experiment used the numbers of hooks between floats and time of fishing typical for tuna-style fishing, but otherwise used swordfish-style methods. Except for using circle hooks on 20% of branch lines, the hook timer fishing experiments used swordfish-style fishing methods.

Gear/Trip type	Swordfish fishing	Tuna fishing
Area fished	North of Hawaiian Islands	South of Hawaiian Islands
Main line length	42 miles	34 miles
Shooter used	No	Yes
Vessel speed	7.8 knots	6.8
Lightsticks used	Yes	No
Branch line length	17 meters	13 meters
Float line length	8 meters	22 meters
No. of hooks	820	1690
No. of hooks per float	4	27
No. of floats	189	66
Type of hook	J-shaped	Tuna
Type of bait	Squid	Saury
Target depth	28 meters	167 meters
Gear soaks	Night	Day
Soak time	20 hours	19 hours

Table 2. Total fishing effort by three vessels fishing simultaneously to test stealth and deep daytime fishing methods for swordfish in comparison with normal (control) swordfish fishing.

Treatment	**Trip #**	**Date**	**Latitude range**	**Sets**	**Hooks**
Control	1	3/15-3/30	28°44-30°28	10	8133
	2	4/13-4/28	28°08-29°43	13	10025
	3	5/10-5/20	26°19-28°00	10	8400
Stealth	1	3/15-3/30	28°10-30°30	10	8220
	2	4/13-4/28	28°30-29°48	13	10522
	3	5/10-5/20	26°27-28°56	10	8183
Deep daytime	1	3/16-3/30	28°01-30°10	10	8200
	2	4/13-4/28	28°01-29°40	13	10660
	3	5/11-5/20	26°11-27°17	10	8200

Table 3. Comparison between landings (fish and pounds) and revenue of control versus stealth and deep daytime fishing for swordfish, FY2002. Landings and revenue data for each vessel were collected at the fish auction in Honolulu after each fishing trip.

Trip no.	Swordfish			Tuna			Others			Total
	No.	Pounds	Gross $	No.	Pounds	Gross $	No.	Pounds	Gross $	Gross $
1	148	17,114	48,199.15	2	255	727.70	23	479	758.00	49684.85
2	122	13048	26984	4	689	4011.8	119	2,223	3,370.90	34,366.70
3	56	5,105	10,879.50	19	2,432	11,939.20	49	1,683	3622.6	26441.3
Totals	**326**	**35,267**	**86,062.65**	**25**	**3,376**	**16,678.70**	**191**	**4,385**	**7,751.50**	**110,492.85**
Stealth swordfish longline										
1	99	11,229	35,720.4	3	389	570.30	9	312	365.60	36,656.30
2	59	5,785	17,069.0	2	288	1,764.90	38	985	1450	20283.95
3	22	2,836	7,520.50	1	185	2,164.50	4	76	266.70	9,951.70
Totals	180	19,850	60,309.9	6	862	4,499.70	51	1,373	2,082.30	66,891.95
%	**45%**	**44%**	**30%**	**76**	**74%**	**73%**	**73%**	**69%**	**73%**	**39%**
1	32	2,508	7,593.30	9	601	1,546.20	6	481	897.60	10,481.10
2	12	1,598	3,446.80	1	164	967.60	68	1,609	2,467.70	6,882.10
3	6	756	1,980.60	15	1,818	9,341.80	39	2,358	3,882.90	15,205.30
Total	**50**	**4,862**	**13,020.7**	**25**	**2,583**	**11,855.60**	**113**	**4,448**	**7,248.20**	**32568.5**
%	**85**	**86%**	**85%**	**0%**	**23%**	**29%**	**41%**	**-1%**	**6%**	**71%**

Table 4. Depth records for the vessels involved in the concurrent trials of deep daytime and stealth swordfish fishing gear in comparison with control (normal swordfish style) fishing.

Treatment	Date	Max depth (psi)	Mean depth (psi)	Max depth (m)	Mean depth (m)
Deep daytime fishing	5/11/02	321.8	208.5	220.5	142.9
	5/11/02	332.8	281.1	228.1	192.6
	5/12/02	324.2	223.9	222.2	153.4
	5/12/02	448.3	398.2	307.2	272.9
	5/13/02	259.5	195.2	177.8	133.8
	5/13/02	454.7	355.3	311.6	243.5
	5/14/02	491.3	377.1	336.7	258.4
	5/14/02	346.1	317.8	237.2	217.8
	5/15/02	550.0	512	376.9	350.9
	5/15/02	508.0	433.7	348.1	297.2
	5/16/02	267.4	239.3	183.3	164.0
	5/16/02	543.4	478.3	372.4	327.8
	5/17/02	545.1	480.1	373.6	329.0
	5/17/02	543.4	541.3	372.4	371.0
	5/18/02	518.2	398.1	355.1	272.8
	5/18/02	543.9	532.8	372.7	365.1
	5/19/02	356.0	271.7	244	186.2
	5/19/02	311.2	201.6	213.3	138.2
	5/20/02	336.0	306.1	230.3	209.8
	5/20/02	441.6	356.6	302.6	244.4
	Mean	**422.1**	**355.4**	**289.3**	**243.6**
Control fishing	5/10/02	108.9	52.8	74.6	36.2
	5/11/02	16.7	12.1	11.4	8.3
	5/12/02	30.5	19.9	20.9	13.6
	5/13/02	60.5	23.6	41.5	16.2
	5/14/02	74.6	38.7	51.1	26.5
	5/15/02	61.6	40.3	42.2	27.6
	5/16/02	24.8	17.1	17.0	11.7
	5/17/02	27.7	19.3	19.0	13.2
	5/18/02	50.7	30.3	34.7	20.8
	5/19/02	21.3	16.1	14.6	11.0
	Mean	**47.7**	**27**	**32.7**	**18.5**
Stealth fishing	5/10/02	23.0	15.1	15.8	10.3
	5/11/02	24.8	17.0	17	11.7
	5/12/02	29.9	19.1	20.5	13.1
	5/13/02	95.9	46.9	65.7	32.1
	5/14/02	85.0	33.9	58.3	23.2
	5/15/02	47.8	29.1	32.8	19.9
	5/16/02	36.3	17.0	24.9	11.7
	5/17/02	25.9	15.9	17.7	10.9
	5/18/02	129.2	63.7	88.5	43.7
	5/19/02	55.8	23.2	38.2	15.9
	Mean	**55.4**	**28.1**	**37.9**	**19.3**

Table 5. Fishing operations conducted by vessels equipped with hook timers. These vessels also tested 18/0 circle hooks on about 20% of the branch lines deployed in the study to test circle hook effectiveness in catching target species.

Treatment	Trip #	Date	Latitude range	Sets	Hooks
Hook timer (1st vessel)	1	4/19-5/8	26°13-29°41	15	12375
	2	5/18-5/30	26°00-27°50	13	10025
	3	6/12-6/30	26°15-29°25	15	12368
	4	7/15-7/31	30°30-35°30	15	12041
Hook timer (2nd vessel)	1	5/22-3/30	26°00-27°32	12	9987
	2	6/18-7/2	27°41-29°52	13	10652
	3	7/16-7/31	29°24-35°05	13	10623

Table 6. Numbers of “J” and 18/0 circle hooks deployed in the hook timer experiments showing the relative effectiveness of circle hooks at catching the target species.

				Swordfish									Tunas								
				"J" hooks catch			"C" hooks catch			"C" effectiveness			"J" hooks catch			"C" hooks catch			"C" effectiveness		
Trip no.	Sets	Hooks	J/C hook ratio	No.	Ave. wt. (lb)	Price (per lb)	No.	Ave. wt. (lb)	Price (per lb)	No.	Lb	$	No.	Ave. wt. (lb)	Price (per lb)	No.	Ave. wt. (lb)	Price (per lb)	No.	Lb	$
1st Vessel																					
1	15	12,375	4.42	136	98	$2.02	18	100	$1.99	58%	60%	59%	12	70	$2.26	8	78	$2.38	294%	326%	344%
2	12	10,025	3.90	157	99	$2.10	24	109	$2.16	60%	66%	68%	10	115	$3.97	1	80	$1.00	39%	27%	7%
3	15	12,368	4.00	187	99	$2.95	21	80	$2.16	45%	36%	27%	21	120	$3.45	5	129	$3.53	95%	102%	104%
4	15	12,020	4.04	203	102	$2.48	10	88	$2.50	20%	17%	17%	21	153	$3.99	2	175	$2.47	38%	44%	27%
Tot.	**57**	**46,788**	**4.10**	**683**	**100**	**$2.44**	**73**	**96**	**$2.16**	**44%**	**42%**	**37%**	**64**	**119**	**$3.60**	**16**	**106**	**$2.54**	**103%**	**91%**	**64%**
2nd Vessel																					
1	12	9,987	4.04	145	95	$2.20	11	61	$1.90	31%	20%	17%	6	102	$5.85	1	145	$6.90	67%	96%	113%
2	13	10,652	4.72	180	102	$2.96	11	84	$2.76	29%	24%	22%	24	118	$1.90	3	109	$2.74	59%	55%	79%
3	13	10,623	6.01	137	89	$1.84	11	81	$1.90	48%	44%	45%	13	128	$2.40	3	135	$3.69	139%	146%	225%
Tot.	**38**	**31262**	**4.83**	**462**	**96**	**$2.41**	**33**	**76**	**$2.25**	**35%**	**27%**	**26%**	**43**	**118**	**$2.65**	**7**	**123**	**$3.74**	**79%**	**82%**	**116**
Both Vessels																					
Tot.	**95**	**78050**	**4.37**	**1,145**	**98**	**$2.43**	**106**	**90**	**$2.18**	**40%**	**37%**	**33%**	**107**	**119**	**$3.26**	**23**	**112**	**$3.02**	**94%**	**89%**	**82%**

Figure 1. Time-depth recorder (TDR) water pressure data (psi = pounds per square inch) from a TDR on the main line while conducting deep daytime swordfish fishing operations. Each pressure mode along the time line (x-axis) represents one day's set. Depth equivalents for these water pressures are given in Table 4.

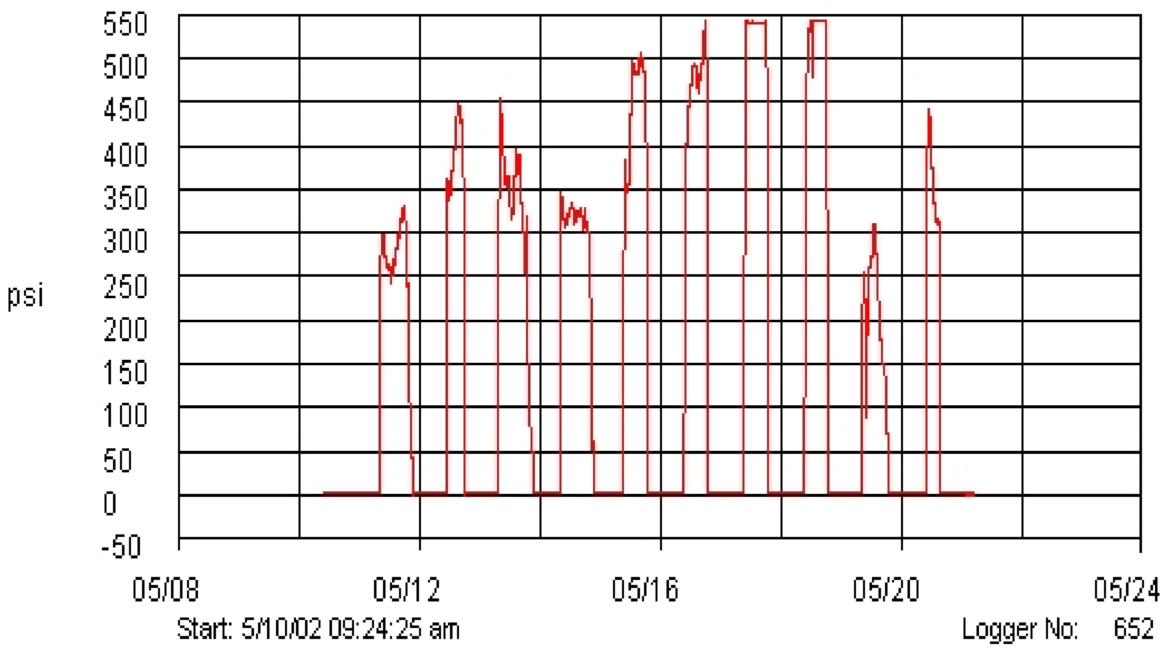
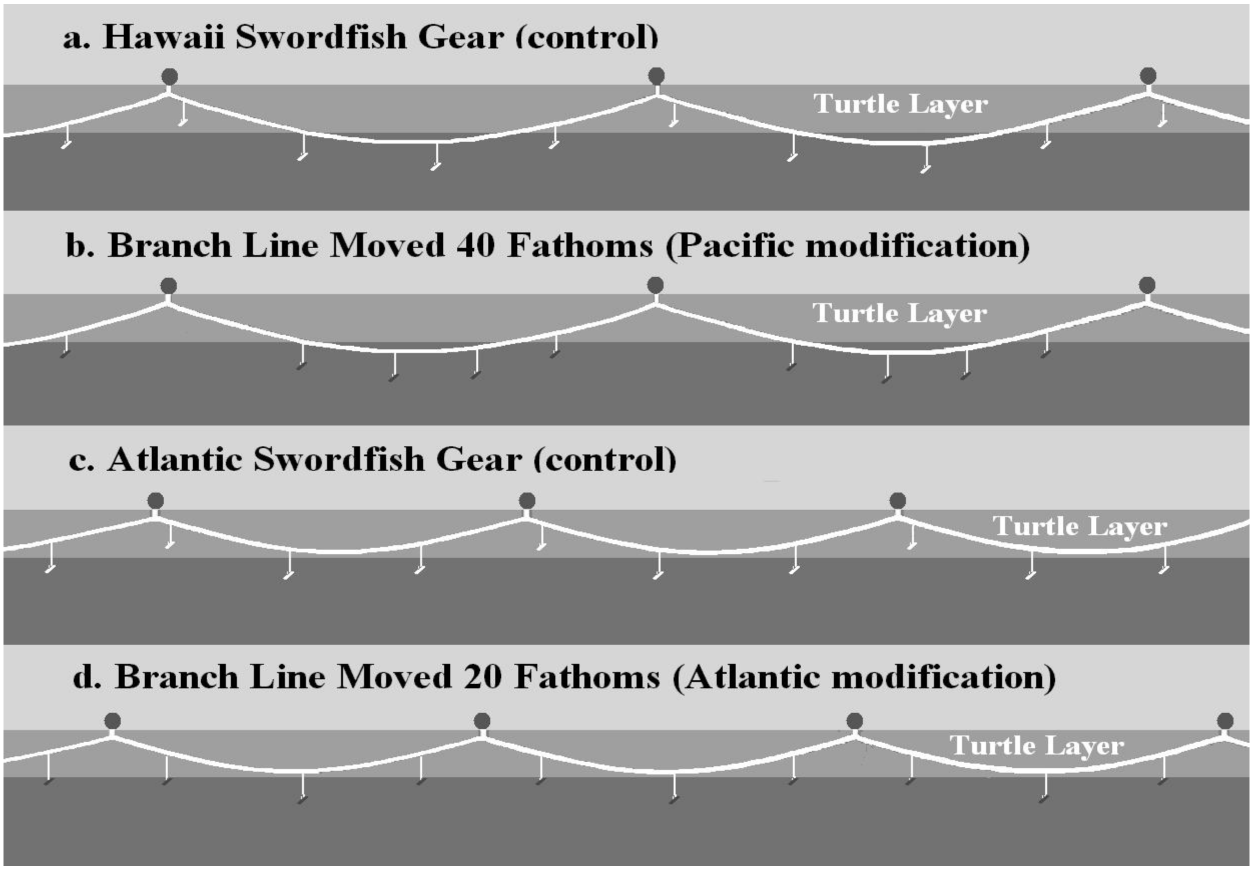


Figure 2. Comparison between Pacific and Atlantic experiments with moved branch lines and blue-dyed bait. The branch line adjacent to the float in normal Hawaii swordfish gear (a) is removed and replaced among the other deep hooks (b) below the hypothesized turtle layer. Atlantic fishermen use fewer hooks between float lines (c). The Atlantic gear modification moved the float line only 20 fathoms away from the adjacent hook by moving it back 20 fathoms closer to the preceding hook (d) and most hooks are set within the shallow "turtle layer."



EXPERIMENT TO EVALUATE GEAR MODIFICATION ON RATES OF SEA TURTLE BYCATCH IN THE SWORDFISH LONGLINE FISHERY IN THE AZORES - PHASE 1 AND PHASE 2

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Background

The problem of sea turtle bycatch in longline fisheries has been recognized worldwide (for review, see Balazs and Pooley 1994, Bolten et al. 1996, Williams et al. 1996). Bolten et al. (1994) and Ferreira et al. (2001) presented data on bycatch of loggerhead sea turtles (Caretta caretta) in the swordfish longline fishery in the Azores. The waters around the Azores are an important developmental habitat for the juvenile oceanic stage of the Atlantic loggerhead population (Bolten 2003). Using mtDNA sequence analyses, Bolten et al. (1998) determined that the source rookeries for this oceanic population are primarily in the southeastern USA. Therefore, the nesting populations of loggerheads in the southeast USA are the primary populations impacted by the swordfish longline fishery in the Azores. Bjorndal et al. (2000, 2003), using a length frequency model and skeletochronology, provided data on growth rates for this juvenile population and determined that the duration of the oceanic stage was 6.5 – 11.5 years depending upon the size at which the turtles departed the oceanic zone for the neritic zone (Figure 1). Annual survival probability for loggerhead turtles of age classes 2 – 6 years representing the size range of turtles that are too small to be caught as bycatch in the longline fisheries was estimated to be 0.911 (Bjorndal et al. 2003). Estimates of annual apparent survival probablility for age classes greater than 6 years representing the size range of turtles caught as bycatch was 0.643; however, this estimate is confounded by emigration from the oceanic zone to the neritic zone (Bjorndal et al. 2003).

A workshop (funded by the U.S. National Marine Fisheries Service) was held in Horta, Azores, Portugal, 2 – 4 September 1998, to review the impact of the swordfish longline fishery on sea turtles and to design an experiment to evaluate gear modification on longline bycatch rates of sea turtles

(Bolten et al. 2000). This Workshop was convened by Alan Bolten (ACCSTR, University of Florida) and chaired by Helen Martins (DOP, University of the Azores) and was attended by commercial longline fishermen from the Azores, fishery biologists from the Department of Oceanography and Fisheries at the University of the Azores, the Director of Fisheries from the Ministry of Agriculture and Fisheries in the Azores, and a representative of the Ministry of the Environment in the Azores. In addition, Jerry Wetherall (NMFS, Honolulu) participated and provided comparative information from other longline fisheries and ensured that the experimental design was statistically rigorous.

Objectives

The objective of this project was to conduct experiments to evaluate effects of gear modification on rates of sea turtle bycatch in the swordfish longline fishery in the Azores. Although the primary objective was to evaluate the effect of hook type on rates of sea turtle bycatch, the effect of hook type on the location of hooking (e.g., mouth vs. esophagus) was also evaluated. The location of hooking has very important implications for the survival of the hooked turtles. Effect of hook type on rates of catch for target species was also evaluated.

Methods

A 25.4-meter commercial swordfish longline vessel (Mestre Bobicha) from the Azores was contracted to conduct the experiment in the waters around the Azores. The experimental design consisted of the following components:

- 93 sets were conducted in Phase 1 between 20 July 2000 – 8 December 2000 (approximately 20 sets per month). 60 sets were conducted in Phase 2 between 2 September 2001 – 6 December 2001 (approximately 20 sets per month).
- Buoy lines were 6-14 meters long, depending on sea conditions.
- There were 8 branchlines between buoys and 45 meters of mainline between each branchline.
- The branchlines were 14 meters long.
- Three hook types were tested in Phase 1: Straight J (Mustad # 76800 D 9/0), Offset J (Mustad # 76801 D 9/0), and Circle (Mustad # 39960 ST 16/0). Three hook types were tested in Phase 2: Straight J (Mustad # 76800 D 9/0), Circle (Mustad # 39960 ST 16/0), and Circle (Mustad # 39960 ST 18/0).
- There were approximately 1500 hooks per set; the number varied depending upon sea conditions (total hooks deployed for the 93 sets of Phase 1 = 138,121 [mean = 1485 hooks

per set]; total hooks deployed for the 60 sets of Phase 2 = 88,150 [mean = 1469 hooks per set]).

- The hooks were individually alternated along the set (that is, A, B, C, A, B, C, A, B…). Since there were 8 hooks between the buoys, the relationship between the hook type and hook position on the gear varied.

- The bait was squid for all sets.

The experiment was conducted during the primary months of the swordfish fishery in the Azores. This time period was treated as one season with no seasonal effect.

Data collected for all turtles caught during the experiment included the following: species, body size (curved carapace length), status (dead, active, sluggish), manner of capture (entangled in line or caught on hook), type of hook, position of hook in the turtle, and position of hook between the buoys. Turtles were tagged with standard flipper tags before release. Small skin samples were collected from all turtles for genetic analyses to monitor source rookeries impacted by this fishery.

Data collected on the fish species caught included the following: species, body size, hook type, and position between the buoys. Environmental parameters were also collected for each set.

Results

- During Phase 1 of the experiment in year 2000, 237 turtles were captured in 93 sets (232 loggerheads, 4 leatherbacks, and 1 green turtle). Catch rate was calculated as 2.5 turtles per set (1.7 turtles per 1000 hooks). The number of loggerheads caught by each hook type is presented in Table 1. The loggerhead catch per 1000 hooks for each hook type is presented in Table 2. All 4 leatherbacks were caught entangled in the line, 2 on lines with straight J hooks and 2 on lines with offset J hooks. The green turtle was caught entangled on a line with a circle hook (16/0).

- During Phase 1, there was no significant difference among the 3 hook types in the number of loggerheads caught (exact binomial tests, $p > 0.05$), although the lower number of turtles caught on the offset J hook approached significance ($p = 0.0509$).

- During Phase 2 of the experiment in year 2001, 45 turtles were captured in 60 sets (44 loggerheads and 1 leatherback). Catch rate was calculated as 0.75 turtles per set (0.51 turtles per 1000 hooks). The number of loggerheads caught by each hook type is presented in Table 1. The loggerhead catch per 1000 hooks for each hook type is presented in Table 2. The leatherback was caught entangled on a line with a larger circle hook (18/0).

- During Phase 2, there was no significant difference among the 3 hook types in the number of loggerheads caught (exact binomial tests, $p > 0.05$), although the higher number of turtles caught on the 16/0 circle hook approached significance ($p = 0.0538$).

- Not all sets caught turtles; turtles were not uniformly distributed but were clustered within the fishing area. The frequency distributions of turtles caught among sets for Phases 1 and 2 are presented in Figure 2.

- The sizes of loggerheads caught on longlines during Phase 1 were significantly larger than the overall sizes of loggerheads in Azorean waters (Kolmogorov-Smirnov test, ks = 0.6522, $p < 0.001$). Mean size of loggerheads caught during Phase 2 (54.7 cm CCL) was significantly larger than the mean size of those caught during Phase 1 (49.8 cm CCL; t-test, $p < 0.0001$). The size range of loggerheads caught on longlines represents the largest turtles in the area (Figure 3).

- For Phases 1 and 2 combined, there was a significant difference among the hook types in the location of the hooks in the turtles (Chi-square = 60.33, df = 1, $p < 0.0001$): 60% of the loggerheads caught on J hooks were hooked in the throat compared with 9% of the loggerheads caught on circle hooks (Table 3). This difference has important implications for sea turtle mortality because throat-hooked turtles would be expected to suffer higher mortality than mouth-hooked turtles.

- The effect of hook position along the mainline on turtle bycatch was not significant during either Phase 1 or Phase 2 (exact binomial tests, $p > 0.05$; Table 4).

- The rate of turtles caught increased significantly as the hour of day of line retrieval increased ($r^2 = 0.86$, $p < 0.001$; Figures 4 and 5). The rate of fish caught remained constant as hour of day of line retrieval increased ($p = 0.7$).

- The number of swordfish (*Xiphias gladius*) caught and the catch per 1000 hooks are presented in Tables 5 and 6, respectively.

- The number of blue shark (*Prionace glauca*) caught and the catch per 1000 hooks are presented in Tables 7 and 8, respectively.

Conclusions

- Experiments can be conducted successfully in the Azores with the commercial fleet, and the results can be exported to other regions and ocean basins.

- High turtle bycatch rate in the waters around the Azores allows for a rigorous experimental design and statistical analyses.

- Use of circle hooks significantly decreased the rate of throat hooking in loggerhead turtles. This result has important implications for reduced sea turtle mortality because throat-hooked turtles would be expected to suffer higher mortality than mouth-hooked turtles.

- Hour of day of longline retrieval had a significant effect on the rate of loggerhead turtles caught. Therefore, retrieval of the longline earlier in the day would reduce the interaction with loggerhead turtles.

- Turtles were not uniformly distributed but were clustered within the fishing area.

- Gear modification has excellent potential to reduce sea turtle mortality in longline fisheries. However, any gear modifications must be evaluated for their effects on other bycatch species as well as target species.

Acknowledgments

We thank the Fisheries Board of the Azores government (DRP-SRAP) for permits to conduct these experiments. We thank the captain and crew of the Mestre Bobicha for their cooperation and dedication to the success of this project. The Department of Oceanography and Fisheries of the University of the Azores provided essential logistic support. This project was funded by US National Marine Fisheries Service contracts to the Archie Carr Center for Sea Turtle Research at the University of Florida: Phase 1 (2000, NA96FE0393), Phase 2 (2001, NA16FM1378). All research was conducted in compliance with the University of Florida IACUC protocols.

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Questions and Discussion

Question: Were post-hooked satellite tagged turtles caught with "J" hooks or circle hooks?

Response: All were hooked in the throat with "J" hooks.

Question: Why are leatherbacks mostly entangled instead of hooked?

Response: It's likely that they are just encountering the gear and they cannot back up. Gangions and leaders are flimsy; stiff monofilament or weighted line may reduce snagging or external entanglement. Most leatherbacks are getting hooked in the shoulder.

Question: What was the fate of post-hooked satellite tagged animals?

Response: As noted earlier, all of the turtles that were tracked were throat hooked with "J" hooks; none of the hooks were removed prior to release. Based on changes in movement and dive behavior, 3 turtles began to show evidence of "recovery" after 8-10 months. These results suggested that there was a significant time when the turtles were not feeding and growing normally. These sublethal effects of hooking may be very significant and the potential for a greater effect of hooking at the population level from sublethal impacts needs to be investigated. Unfortunately, battery life of the transmitters prevented us from following the fates of these turtles for a longer time frame.

Question: Was temperature a factor in the large number of sets with no turtle takes?

Response: No, temperature was not a factor, but we may need to investigate bathymetric features as there are convergence zones in the area. Temperature was approximately 24°C.

Question: Was there evidence of multiple hooked turtles?

Response: No.

Question/Comment: For tagging studies conducted in Costa Rica, results also illustrated that hooked turtles remained shallow for about 6months before resuming deeper dives. However, they removed hooks when possible. Were controls lightly hooked?

Response: Controls were hand caught independent of the longline fishery.

Table 1. The effect of hook type on the numbers of loggerhead turtles caught. There were 93 sets in 2000 (138,121 hooks) and 60 sets in 2001 (88,150 hooks). There was no significant difference among the 3 hook types within each year in the number of loggerheads caught (see text).

Hook Type	**Phase 1 (year 2000) 93 sets – 138,121 hooks**	**Phase 2 (year 2001) 60 sets – 88,150 hooks**
Straight J (9/0)	84	14
Offset J (9/0)	63	---
Circle (16/0)	85	21
Circle (18/0)	---	9
Total	232	44

Table 2. The CPUE of loggerheads per 1000 hooks for each hook type.

Hook Type	**Phase 1 (year 2000) 93 sets – 138,121 hooks**	**Phase 2 (year 2001) 60 sets – 88,150 hooks**
Straight J (9/0)	0.61	0.16
Offset J (9/0)	0.46	---
Circle (16/0)	0.62	0.24
Circle (18/0)	---	0.10

Table 3. The effect of hook type on the location of the hook in the captured loggerhead turtles; data for Phase 1 and Phase 2 are combined. J style hooks had a significantly higher rate of throat capture compared with circle hooks (Chi-square = 60.33, df = 1, $p < 0.0001$); 60% of the loggerheads caught on J style hooks were hooked in the throat compared with 9% of the loggerheads caught on circle hooks.

Hook Type	External	Mouth	Throat	Total
Straight J (9/0)	12	34	51	97
Offset J (9/0)	14	20	29	63
Circle (16/0)	12	85	9	106
Circle (18/0)	3	6	0	9

Table 4. Effect of hook position between the buoys on loggerhead capture during Phases 1 and 2. The position of the 8 hooks between each buoy were scored as: 1, 2, 3, 4, 4, 3, 2, 1; where position 1 was nearest the buoy. The effect of hook position was not significant (exact binomial tests, $p > 0.05$) in either Phase 1 or Phase 2.

Hook Position	Number of Loggerheads Phase 1	Number of Loggerheads Phase 2
1	65	10
2	50	12
3	53	13
4	55	5

Table 5. Effect of hook type on the numbers of swordfish caught.

Hook Type	Phase 1 (year 2000) 93 sets – 138,121 hooks	Phase 2 (year 2001) 60 sets – 88,150 hooks
Straight J (9/0)	382	203
Offset J (9/0)	341	---
Circle (16/0)	264	220
Circle (18/0)	---	137
Total	987	560

Table 6. Effect of hook type on swordfish CPUE per 1000 hooks.

Hook Type	Phase 1 (year 2000) 93 sets – 138,121 hooks	Phase 2 (year 2001) 60 sets – 88,150 hooks
Straight J (9/0)	2.8	2.3
Offset J (9/0)	2.5	---
Circle (16/0)	1.9	2.5
Circle (18/0)	---	1.6

Table 7. Effect of hook type on the numbers of blue shark caught.

Hook Type	**Phase 1 (year 2000)** **93 sets – 138,121 hooks**	**Phase 2 (year 2001)** **60 sets – 88,150 hooks**
Straight J (9/0)	733	896
Offset J (9/0)	600	---
Circle (16/0)	796	1619
Circle (18/0)	---	1476
Total	2129	3991

Table 8. Effect of hook type on blue shark CPUE per 1000 hooks.

Hook Type	**Phase 1 (year 2000)** **93 sets – 138,121 hooks**	**Phase 2 (year 2001)** **60 sets – 88,150 hooks**
Straight J (9/0)	5.3	10.2
Offset J (9/0)	4.3	---
Circle (16/0)	5.8	18.4
Circle (18/0)	---	16.7

Figure 1. Size-frequency distributions of oceanic-stage loggerheads captured in waters around the Azores (left-hand curves, n = 1692) and neritic-stage loggerheads stranded in southeastern USA (right-hand curves, n = 1803) (modified from Bjorndal et al. 2000, 2001). Percentages were calculated for each population. Dashed lines are cubic smoothing splines (df = 15); vertical reference line is at the intersection of the two smooths at 53 cm CCL.

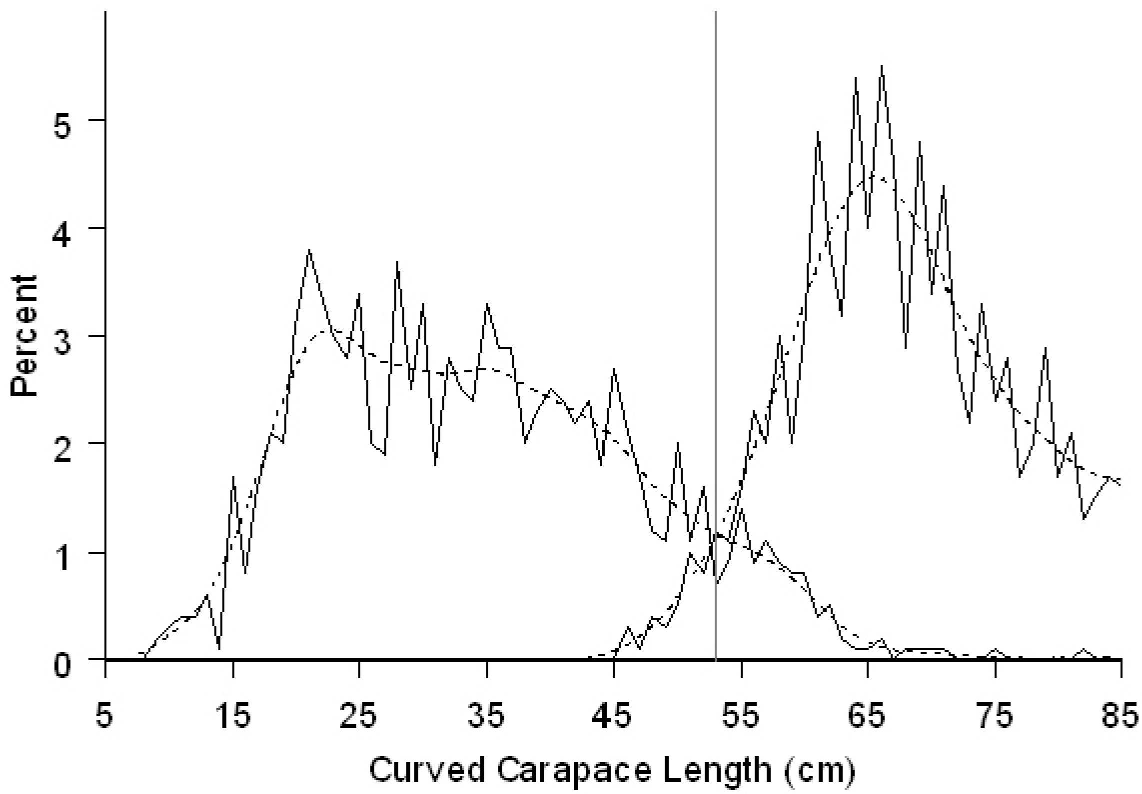


Figure 2. Frequency distributions of the number of turtles caught per set during Phases 1 (open bars) and 2 (solid bars).

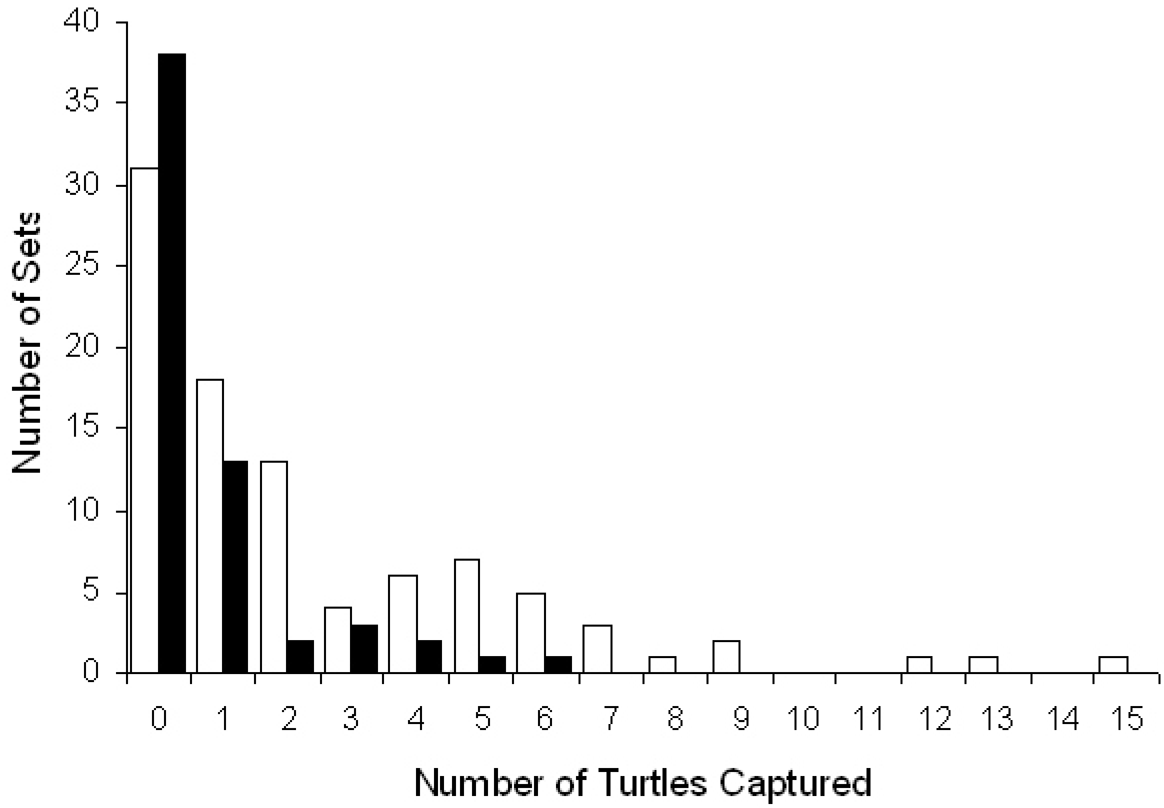


Figure 3. The size distribution of loggerhead turtles caught on the swordfish longline during Phases 1 (open bars) and 2 (solid bars) of the experiment compared with the overall size distribution of loggerheads in Azorean waters (gray bars, data from Bjorndal et al. 2000). The sizes of loggerheads caught during Phase 1 were significantly larger than the overall sizes of loggerheads in Azorean waters (Kolmogorov-Smirnov test, ks = 0.6522, $p < 0.001$). Mean size of loggerheads caught during Phase 2 (54.7 cm CCL) was significantly larger than those caught during Phase 1 (49.8 cm CCL; t-test, $p < 0.0001$).

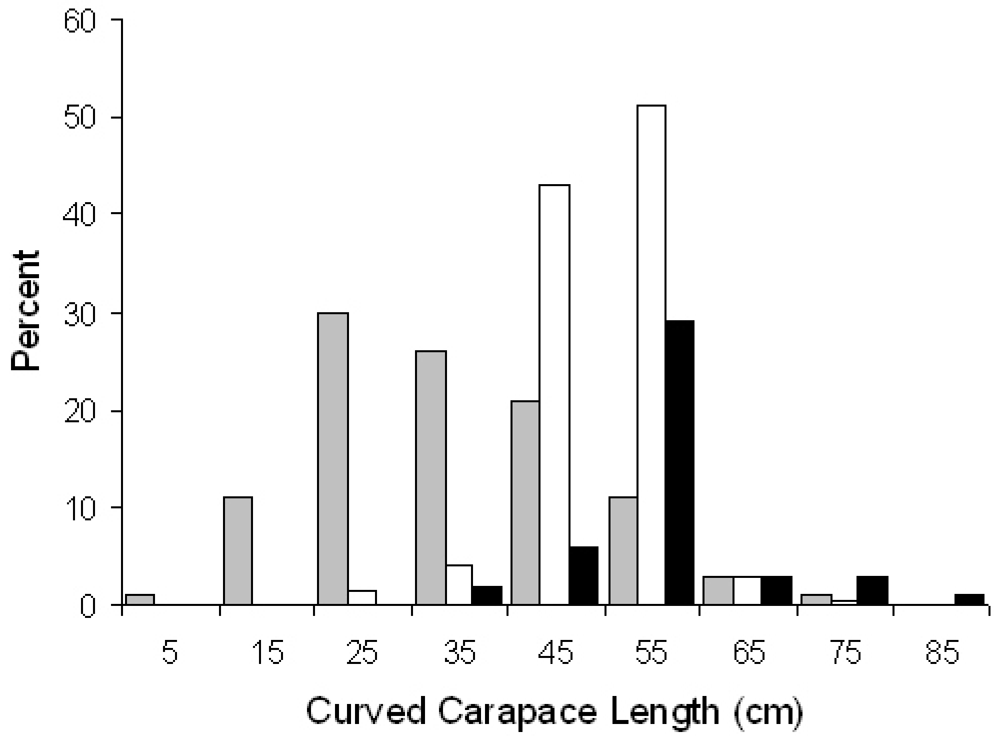


Figure 4. The relationship between both the rate of turtles caught and the rate of fish caught and the hour of day that the longline was retrieved during Phase 1 of the experiment in 2000. The rate of turtles caught increased as the hour of day increased (see Figure 5). The rate of fish caught remained constant as hour of day of line retrieval increased (p = 0.7).

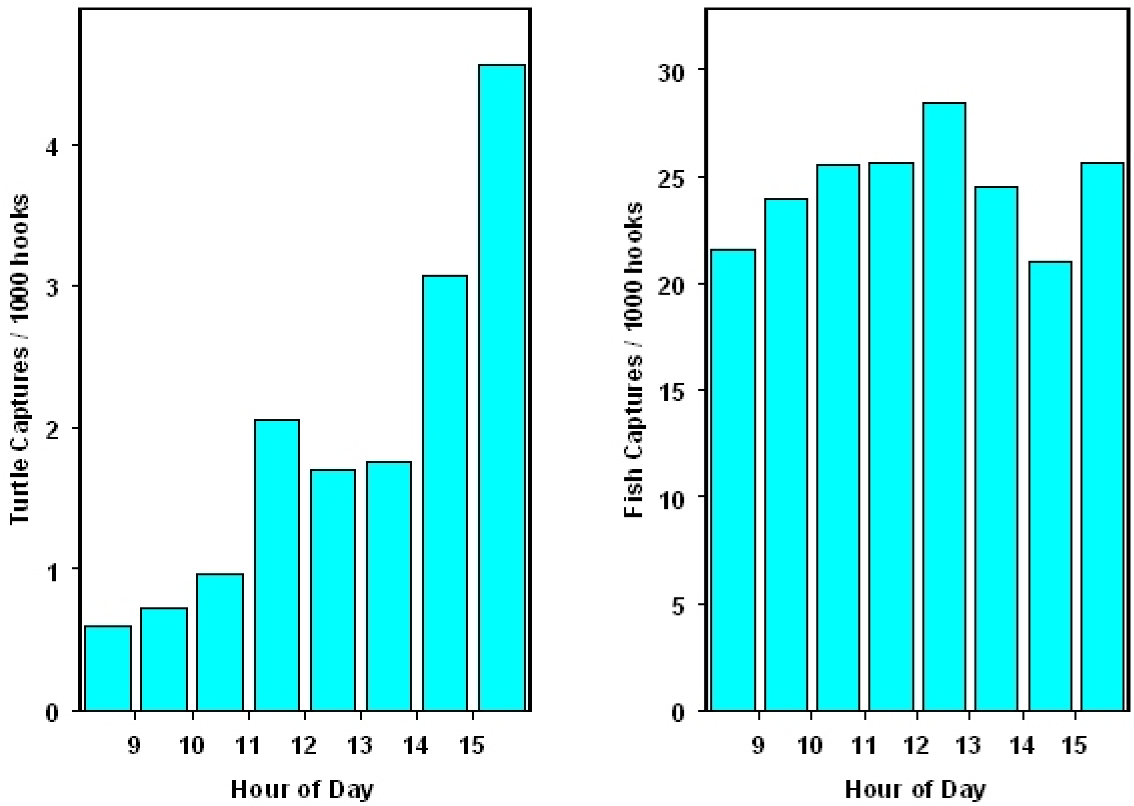
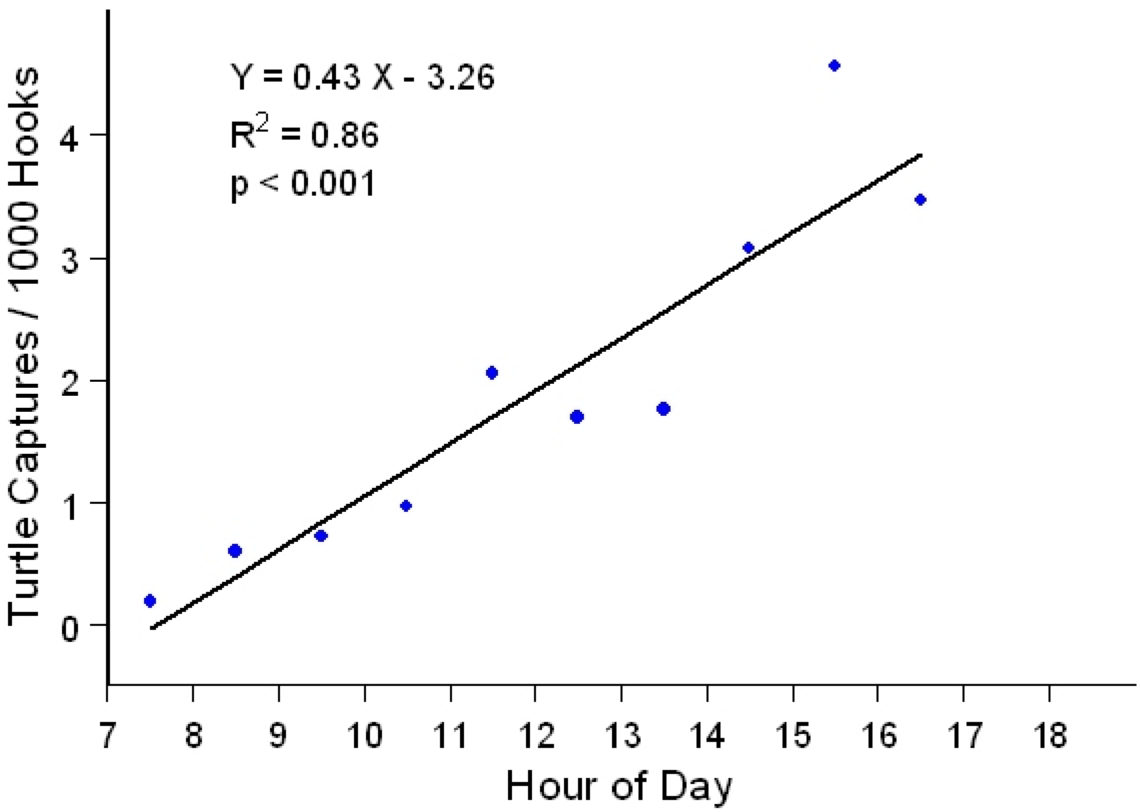


Figure 5. The relationship between the rate of turtles caught and the hour of day that the longline was retrieved during Phase 1 of the experiment in 2000. There was a significant effect in the rate of turtles caught as the hour of day of longline retrieval increased ($r^2 = 0.86$, $p < 0.001$).



INVESTIGATIONS OF SEA TURTLE AND PELAGIC FISH SENSORY PHYSIOLOGY AND BEHAVIOR, WITH THE AIM OF DEVELOPING TECHNIQUES THAT REDUCE OR ELIMINATE THE INTERACTIONS OF SEA TURTLES WITH FISHING GEAR

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The interactions of sea turtles with longline fishing gear have resulted in severe time-area closures for the U.S. longline fleet. However, this approach to bycatch reduction is not readily exportable to foreign fishing nations. Additionally, non-U.S. longline fleets continue to operate in areas vacated by U.S. vessels. Moreover, turtles and targeted fish species are likely orienting to similar cues that define the patchy forage concentrations of the pelagic environment, so their distributions often overlap. Thus time-area closures are unlikely to be simultaneously effective at reducing turtle-fishing gear interactions and acceptable to the fishery.

A more effective long-term resolution would be the development of techniques and/or gear modifications that reduce the incidence or severity of hooking turtles to acceptable levels, but that maintain an economically viable catch rate of targeted species. However, in order for any technique/gear modification to reduce sea turtle bycatch globally, it must be all of the following: relatively inexpensive, readily available, easy to use, and easy to enforce. Ideally it would also require minimal direct effort on the part of fishers.

Defining and exploiting differences in sea turtle and fish sensory physiology (either vision, hearing, or olfaction) is one possible approach for addressing these issues. Because sea turtles, which evolved from terrestrial reptiles, and commercially targeted fish are so evolutionarily distant, their sensory capabilities should have conclusive differences. Discovering these differences should be readily viable.

An international collaborative investigation, funded through the National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center is currently underway to do just this. The projects are intended to characterize vision, hearing, olfaction, and gustation in sea turtles, so that a comprehensive assessment of potential sensory attractants and repellants may be made. The overall plan is to proceed simultaneously along several tracks employing modern molecular genetic techniques (to identify receptor molecules), standard electrophysiological methodologies (to record responses to specific stimuli and define detection thresholds), and behavioral experiments using several species of sea turtles and pelagic fishes. Because of the complexity of the research, the projects necessarily involve a large and diverse team of scientists. The immediate objective is to define specific and exploitable differences in the visual, auditory, and olfactory capabilities of sea turtles and commercially important pelagic fishes (e.g., tunas and billfishes). The overall objective, however, is development of devices or techniques that make fishing gear repulsive (or at least less attractive) to sea turtles, but that are undetectable by the targeted fish species.

The specific projects included in this effort are briefly described below. Readers requiring more information should contact any the authors of this report, or the investigators themselves.

Odor Receptors and Olfaction in Sea Turtles

Project 1. Complete characterization of Olfactory Receptor (OR) genes from green, leatherback, and loggerhead sea turtles and development of a list of classes potentially stimulatory compounds. This project may include attempts to clone and express turtle olfactory genes in nematodes. If this is successful, then large numbers of chemicals could be rapidly screened using a simple and inexpensive behavioral assay. Participating investigator: Richard Vogt, Department of Biological Sciences, University of South Carolina.

Project 2. Develop robust behavioral assays for qualifying responses to attractive odors, repulsive odors, and odor masking in sea turtles and pelagic fishes. Studies to be conducted at NMFS Honolulu and Galveston Laboratories, University of North Carolina and University of South Carolina. Participating investigators (in alphabetical order): Ben Higgins, NMFS, Galveston Laboratory; Kenneth Lohmann, Department of Biology, University of North Carolina; Amanda Southwood, University of Hawaii; Yonat Swimmer, NMFS Pacific Islands Fisheries Science Center; Richard Vogt, Department of Biological Sciences, University of South Carolina.

Project 3. Test the efficacy of modified baits, fishing gear, and repellent chemicals to reduce the incidence of gear interactions using captive turtles and pelagic fishes held at the NMFS Galveston Laboratory and NMFS Pacific Islands Fisheries Science Center (Kewalo Research Facility). Participating investigators: Ben Higgins, NMFS, Galveston Laboratory; Amanda Southwood, University of Hawaii; Yonat Swimmer, NMFS Pacific Islands Fisheries Science Center.

Auditory Capabilities of Sea Turtles and Pelagic Fishes

The results obtained to date show that both sea turtles and pelagic fishes detect the same low frequency and high energy (i.e., loud) sounds. It is, therefore, unlikely that "pingers" could be used to deter sea turtles from longline gear. Efforts in this project, therefore, currently center on completing turtle and tuna hearing experiments already in progress. As there is some possibility that sea turtles may be attracted to the sound produced by longline floats, studies will also be carried out to determine the sound spectrum and sound pressure levels produced by both hard and soft floats used in longline fishing. Experiments will be conducted at NMFS Galveston Laboratory, the NMFS Pacific Islands Fisheries Science Center (Kewalo Research Facility), and the New England Aquarium. Participating investigators: Soraya Moein Bartol and Darlene Ketten, Woods Hole Oceanographic Institute.

Visual Capabilities of Sea Turtles and Pelagic Fishes

Project 1: Characterize color vision in sea turtles using the electroretinographic (ERG) technique. Studies on loggerhead and green turtles have been completed, however similar work on leatherback, hawksbill, and olive ridley turtles remains to be done. As these species are not available in captivity, additional ERG studies must necessarily be done in the field. The ERG work will be directly tied to the continuing project using molecular biological techniques to characterize genes responsible for producing visual pigments present in turtles . Participating investigators: Michael Crognale, Department of Psychology, University of Nevada, Reno; Scott Eckert, WIDECAST; David Levenson, Scripps Institute of Oceanography.

Project 2: Define color vision in pelagic fish and sea turtles, and the speed of vision in pelagic fish and sea turtles, using the isolated retina technique. Results to date (in conjunction with Project 1, above) show promising differences in the color sensitivity, speed, and day-night changes in the visual capabilities of sea turtles and pelagic fishes (e.g., swordfish and tunas). It is, therefore, beginning to appear that electronic light sticks could be designed that are repulsive to sea turtles (or that are at least less attractive than the chemical light sticks currently in use), but that would not reduce catch rates of the targeted pelagic fishes due do differences in visual capabilities. This project is currently employing electro-physiological (both extracellular and single-cell recording) and histological techniques, as well as micro-spectrophotometry, to characterize the visual systems of sea turtles and pelagic fishes. These data will, in turn, be used to develop and refine models (see Project 4 below) of sea turtle and pelagic fish vision under various combinations of light levels and temperature. Participating investigators: Kerstin Fritches, Vision, Touch and Hearing Research Center, University of Queensland; Eric Warrant, Department of Zoology, University of Lund.

Project 3: Determine the relative attractiveness and deterrence of electronic "light sticks" to sea turtles using behavioral tests. Based on results from Project 2 (described above), the efficacy of specifically designed electronic light sticks seems promising for reducing turtle-longline interactions. This project will continue and expand on previous behavioral studies. Besides testing specifically designed electronic light sticks, the attractiveness of various wave lengths (i.e., colors), flashing lights, and light patterns simulating motion are also being examined. Participating investigators:

Soraya Moein Barton, Woods Hole Oceanographic Institute; Michael Crognale, Department of Psychology, University of Nevada, Reno; Ben Higgins, NMFS Galveston Laboratory; Peter Lindgren, Lindgren-Pitman, Inc.; Kenneth Lohmann, Department of Biology, University of North Carolina.

Project 4: Develop computer models of pelagic fish and sea turtle visual capabilities at various light levels and depths. This project represents the culmination of Projects 1 and 2 described above. The objective is to develop techniques that allow the accurate predication of the visibility of longline fishing gear to various targeted fish species and sea turtles. Participating investigators: Sonke Johanson, Duke University; Eric Warrant, Department of Zoology, University of Lund.

Project 5: Develop a "turtle scarecrow". Behavioral experiments conducted in turtle holding pens at the NMFS Panama City Laboratory clearly showed that loggerhead turtles raised in captivity from hatchlings will avoid (and in most cases actively flee) a realistic shark model. The objective of this project is to learn specifically what features of the model (e.g., large eye, jaws, teeth, body shape, relative fin position, or silhouette) serve to elicit such strong escape behaviors. Once this is determined, it may be possible to reshape longline floats, or provide other simple structures, to deter sea turtles from longline gear. Participating investigator: Ben Higgins, NMFS Galveston Laboratory.

Development of Rearing Techniques for Hatchling Leatherback Turtles, with the Objective of Supplying Juvenile Animals for Behavioral and Sensory Biology Research, Prior to Their Release Back into the Wild

Leatherback sea turtles are not held in captivity anywhere, which severely limits research on this critically endangered species. Although the projects described above are attempting to circumvent this problem by extrapolating results from genetic, sensory physiology, and behavioral studies on hard shell turtles to leatherbacks, this approach does have limitations. Leatherback hatchlings are available from Florida that are in such condition that chances of survival in the wild are nil. These so-called "salvaged hatchlings" would be ideal for development of captive rearing techniques. This project is intended to provide a source of animals for a host of scientific studies. Participating investigator: Ben Higgins, NMFS Galveston Laboratory.

Questions and Discussion

Question: Do bigeye tuna and swordfish have similar vision?

Response: Yes, both bigeye and swordfish have monochromatic vision and see the same blue green wavelength.

FORAGE AND MIGRATION HABITAT OF LOGGERHEAD (CARETTA CARETTA) AND OLIVE RIDLEY (LEPIDOCHELYS OLIVACEA) SEA TURTLES IN THE CENTRAL NORTH PACIFIC OCEAN

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Abstract

Satellite telemetry from 26 loggerhead (*Caretta caretta*) and 10 olive ridley (*Lepidochelys olivacea*) sea turtles captured and released from pelagic longline fishing gear provided information on the turtles' position and movement in the central North Pacific. These data, together with environmental data from satellite remote sensing, are used to describe the oceanic habitat used by these turtles. The results indicate that loggerheads travel westward, move seasonally north and south primarily through the region 28°- 40°N latitude, and occupy sea surface temperatures (SST) of 15°- 25°C. Their dive depth distribution indicated that they spend 40% of their time at the surface and 90% of their time at depths less than 40 m. Loggerheads are found in association with fronts, eddies, and geostrophic currents. Specifically, the Transition Zone Chlorophyll Front (TZCF) and the southern edge of the Kuroshio Extension Current (KEC) appear to be important forage and migration habitats for loggerheads.

In contrast, olive ridleys were found primarily south of loggerhead habitat in the region 8°- 31° N latitude, occupying warmer water with SSTs of 23°- 28° C. They have a deeper dive pattern than loggerheads, spending only 20% of their time at the surface and 60% shallower than 40 m. However, three olive ridleys identified from genetics to be of western Pacific origin spent some time associated with major ocean currents, specifically the southern edge of the KEC, the North Equatorial Current (NEC), and the Equatorial Counter Current (ECC). These habitats were not used by any olive ridleys of eastern Pacific origin, suggesting that olive ridleys from different populations may occupy different oceanic habitats.

Questions and Discussion

Question/Comment: Some tracks show movement through corridors that may not be related to habitat, possibly more dependent on foraging. Could observer data be useful in separating these factors?

Response: Yes, we have currently merged observer data with sea surface temperature data.

SEABIRD BYCATCH REDUCTION RESEARCH AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

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(Written summary prepared from author's powerpoint presentation by the editors.)

PURPOSE OF PRESENTATION

- While developing gear and/or technologies to reduce turtle bycatch in longline fisheries, we don't want to increase bycatch of seabirds or vice versa

- The following presentation focuses on the components of effective seabird bycatch reduction programs

WHY DO BIRDS GET CAUGHT IN LONGLINE GEAR?

- The vast majority of birds are taken during gear deployment before hooks sink out of reach. Some birds are taken infrequently during hauling operations, but can be released alive with proper handling techniques.

- Seabirds are attracted to vessels because of the bait and offal

- If bait is unprotected, birds can become hooked

HISTORY OF SEABIRD BYCATCH MANAGEMENT ACTIONS

- Addressing bycatch of globally occurring species requires working through international organizations, governmental and regional fishery management organizations

- Mid-1980s - Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) first noticed bycatch of seabirds in bottom longline fisheries

- Early 1990s - Commission for the Conservation of Southern Bluefin Tuna (CCSBT) first considered seabird bycatch in pelagic tuna fisheries
  - 1991 to present - Real Time Monitoring Program instituted by Japan to actively collect various information on Southern bluefin tuna and related species through a scientific observer program
  - 1997 - Tori Pole streamer mandated by CCSBT

- 1999 - Efforts by the U.S. and Japan led to the Food and Agriculture Organization's (FAO) Committee on Fisheries adoption of an International Plan of Action (IPOA) to address incidental bycatch of seabirds in longline fisheries
  - IPOA calls for member countries to assess their longline fisheries and determine if a seabird problem exists, if so, then member countries need to develop a National Plan of Action to implement measures for reducing bycatch

<u>IFF2 SEABIRD MITIGATION BREAKOUT SESSION</u>

■ Main objective: to identify and discuss best existing seabird mitigation practices and research needed to evaluate new and current mitigation measures for various longline gear systems.

■ Gear systems addressed:
- Pelagic - target species include tuna, swordfish, billfish
- Demersal - target species include groundfish, halibut, ling, cod
- Spanish Demersal - target species include Patagonian toothfish

■ Methods to reduce seabird bycatch
- Reduce availability of baited hooks by:
  - Streamer lines
  - Integrated line weighting
  - Underwater chute setting
- Reduce detection of baited hooks by:
  - Blue-dyed bait (i.e., stealth gear)
  - Strategic offal discharge
  - Night setting
- Reduce attractiveness of vessels to seabirds by:
  - Offal management / retention

■ Improved mitigation results from:

- Better crew training
- Expanded testing in different regions
- New vessel construction
- Development of minimum standards

■ Outcomes
- All mitigation strategies listed here and discussed at IFF2 were considered effective in reducing seabird bycatch
- Each strategy has strengths, weaknesses, and need for further research
- Participants agreed that new technologies are not needed; fine-tuning and broadening of existing mitigation practices is more important
- A suite of management measures will prove most effective, similar to the FAO's International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries

<u>KEY RESEARCH PROJECTS PRESENTED AT IFF2</u>

■ Washington Sea Grant Program and University of Washington
- Compared seabird bycatch strategies from 1999-2000 in Alaska demersal longline fisheries
- Collaborative approach with industry and resource agencies
- Identified and tested possible deterrents on active fishing vessels under typical fishing conditions, specifically:
    - Paired streamer lines
    - Single streamer lines
    - Weighted groundline
    - Line shooter
    - Lining tube
    - Combination of paired lines and weighted groundlines
- Results
    - Paired streamer lines of specified performance and material standards successfully reduced seabird bycatch in all years, regions, and fleets (88-100% relative to controls with no deterrent)
    - Single streamer lines were slightly less effective, reducing bycatch 71-96%
    - A proposed rule was published in the *Federal Register* (68 FR 6386) to revise existing regulations for Alaska longline fisheries based on these findings
    - Weighted gear, recognized as one of the most effective methods, sinks gear more quickly, which:
        - Reduces visual cues
        - Reduces time for surface seizing

        - Increases difficulty for diving species to make contact with baited hooks
    - Weighted gear was deemed impractical due to safety concerns

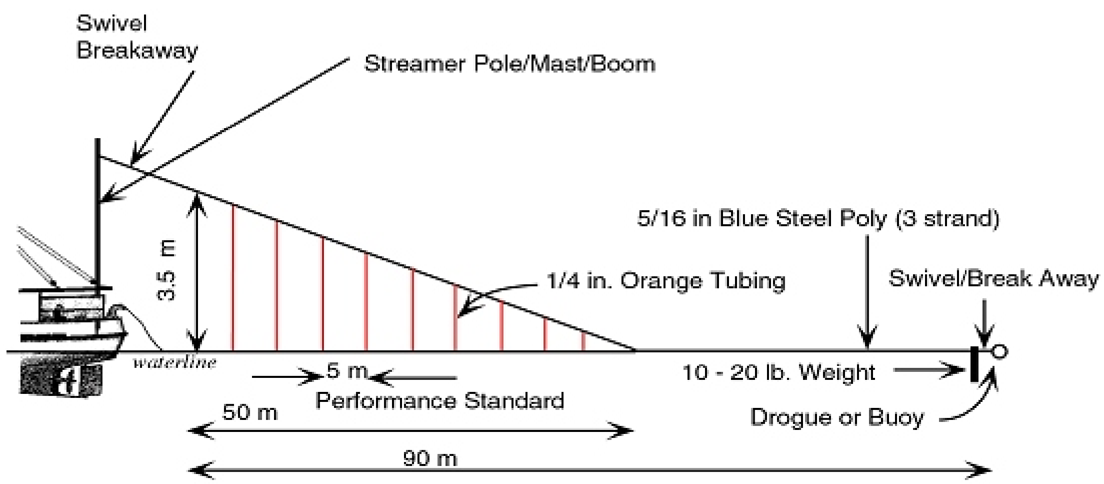

Figure 1. Schematic illustrating performance standards for a seabird streamer line that if adhered to will result in reductions in the incidental catch of seabirds. (Figure courtesy of Ed Melvin, Washington Sea Grant Program.)

- Collaborative project between Fiskevegn and industry in Alaska and New Zealand
    - Developed prototype integrated weight line
    - Observations from research in New Zealand
        - All integrated weight line sank immediately upon entering water
        - All integrated weight line was heavy enough to counter the upward thrust of the propeller
    - Unweighted lines were still visible just below the surface and appeared to stay there due to propeller turbulence
    - Preliminary results from New Zealand
        - 25 birds caught on unweighted lines
        - No birds caught on integrated weight line
        - Skipper/crew prefer integrated weight line (e.g., “Integrated weight line is coiling better and retaining a memory, and there is no need to attach external weights.”)
    - Preliminary results from research conducted in Alaska by the Washington Sea Grant Program (Figure 2)

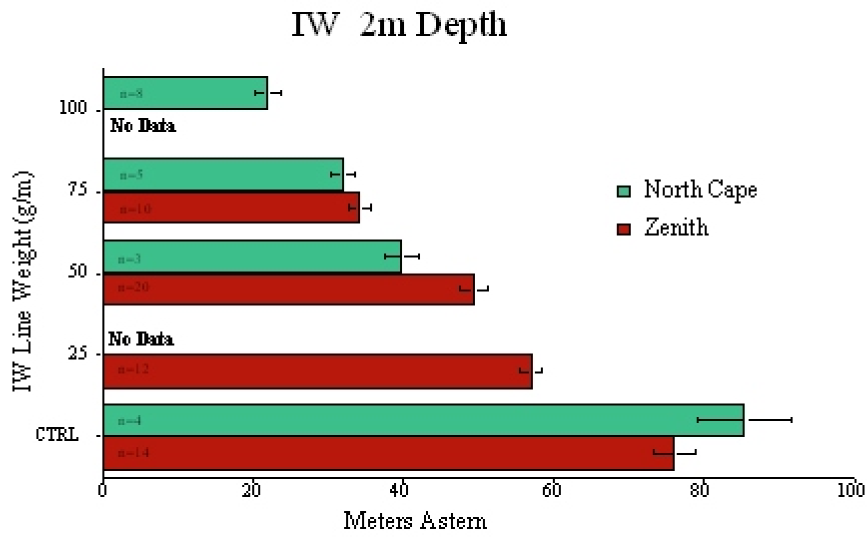

Figure 2. Results of preliminary research conducted in Alaska on various integrated line weights. Figure courtesy of Ed Melvin, Washington Sea Grant Program.

- Research in Alaska, New Zealand, and Australia is ongoing
- Falklands Conservation and Consolidated Fisheries, Ltd.
    - Identified a suite of best practices for Spanish demersal longlines and conducted various research on paired and single streamer lines
    - Spanish demersal system is common gear for Antarctic and South American fisheries, particularly noted for extreme depths (i.e., toothfish sets), rough terrain, and reduction in gear loss.

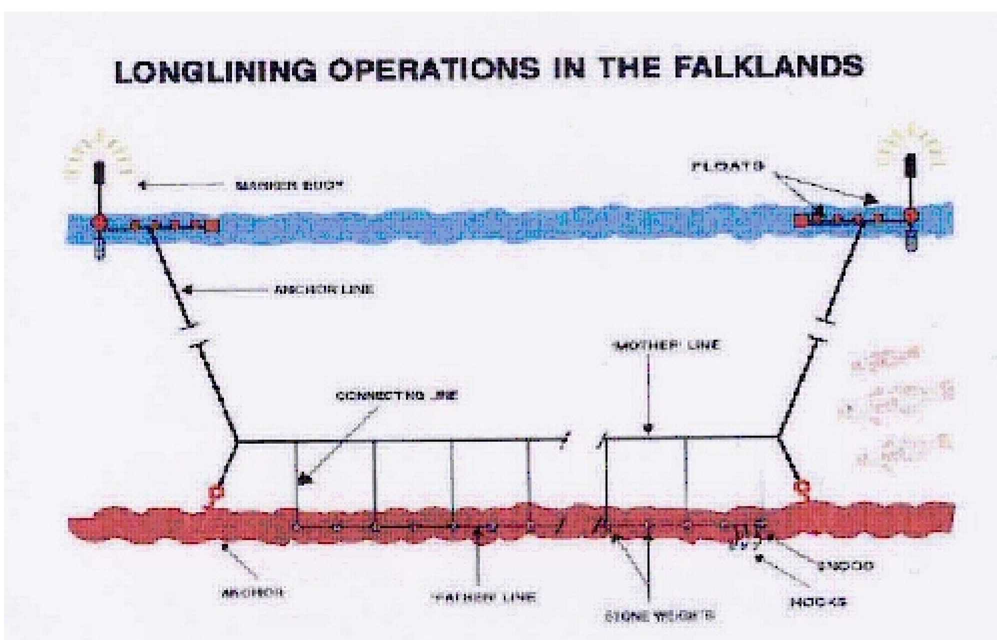

Figure 3. Schematic of the 'dual line' or Spanish longline system used in longlining operations in the Falkland/Malvinas Islands. (Figure courtesy of Ben Sullivan, Falklands Conservation, Seabirds at Sea Team.)

- Best practices
    - Standard specifications (e.g., CCAMLR, Alaska)
    - Multiple lines (e.g., swivels, long streamers)
    - Effective length (e.g., 120-150m)
        - Buoy for drag on seaward end increases tension
        - Attachment point/system
    - Operational modifications
        - Increase width of side arms to increase effectiveness in cross winds
- Researching and developing a setting chute, possibly underwater, for the complex double-line Spanish system to reduce amount of weight needed to add or integrate to a groundline (Figure 4).

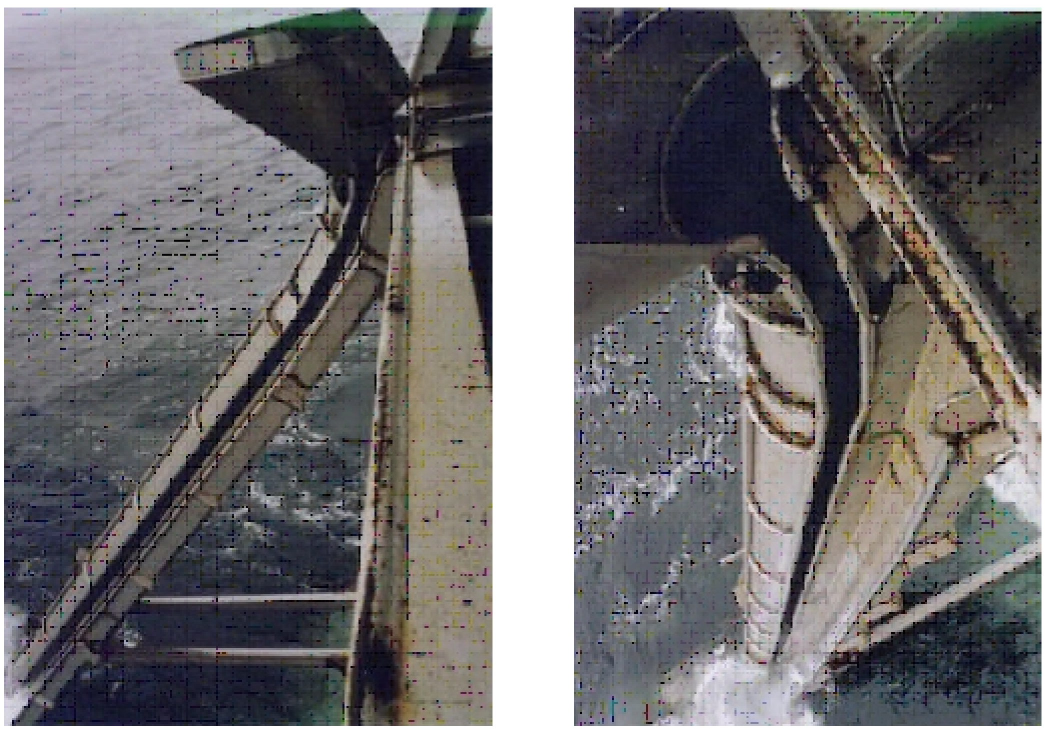

Figure 4. Photos of underwater setting chutes used to deploy the baited gear sub-surface where birds cannot access the baited hooks. (Photos courtesy of Ben Sullivan, Falklands Conservation, Seabirds at Sea Team.)

■ Hawaii cooperative research program - National Audubon Society, Hawaii Longline Association, NOAA Fisheries, Western Pacific Regional Fishery Management Council, Fish and Wildlife Service, and Albi Save (Australian chute manufacturer)
- Evaluated the effectiveness of a practical underwater setting device for pelagic longlines to reduce seabird interactions
- Chute was 95% effective at reducing albatross contacts
- Second phase of the study will test modifications to a shorter chute and explore 'side setting'

- Japanese National Research Institute of Far Seas Fisheries
    - Working with tuna longline fishermen to reduce incidental take of seabirds by using blue-dyed bait (i.e., stealth gear)
    - Blue-dyed bait was prepared onshore due to rough seas in the North Pacific and Southern Ocean
        - Bait (squid and sardine) were thawed and soaked in Brilliant Blue FCF for 20-30 minutes
        - Results from a Southern bluefin tuna longline survey off Cape Town, South Africa illustrate no significant differences in target catch rates between the two baits; there were no birds taken when blue-dyed bait was utilized (Figure 5)
        - Concluded that blue-dyed bait was effective in reducing incidental take of seabirds (Figure 5)

Southern Bluefin Tuna | Seabirds

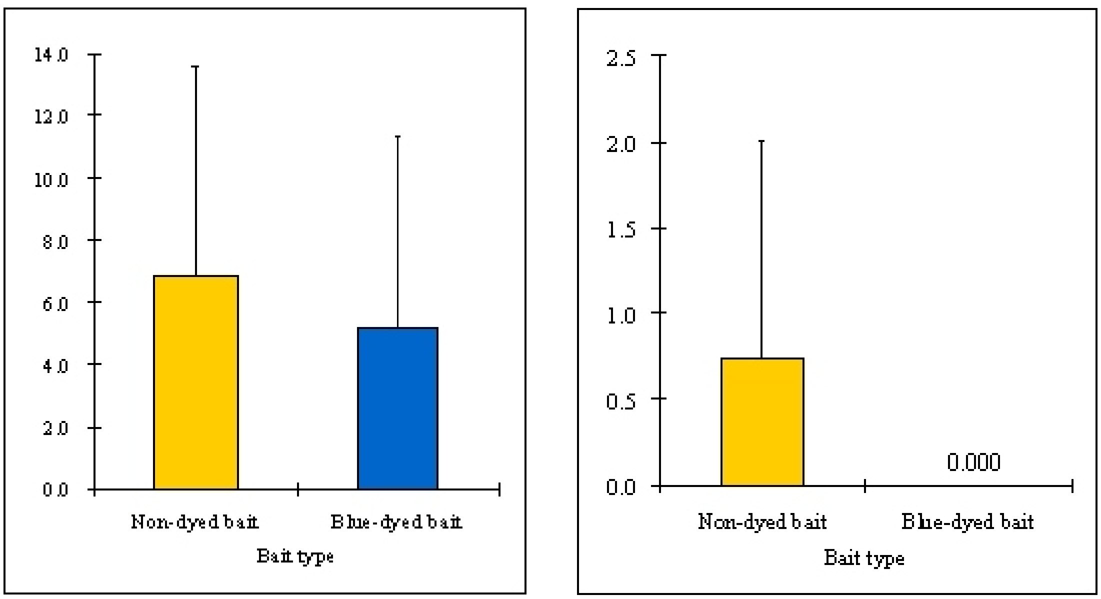

Figure 5. Catch rates (number of catch/1,000 hooks) (on x-axis) of Southern Bluefin Tuna and seabirds using dyed bait in tuna longline fishery in high sea. Figure courtesy of Hiroshi Minami, National Research Institute of Far Seas Fisheries, Japan.

- NOAA Fisheries Pacific Islands Science Center
    - Study conducted in 1999 to examine effectiveness of albatross deterrent techniques during line-setting operations in the Hawaii-based swordfish longline fishery
    - Evaluated bird streamer lines, weights added to bait, and blue-dyed bait
    - Blue-dyed bait reduced the number of contacts between bait and blue footed albatross and Laysan albatross by about 90%
    - Streamer lines reduced number of contacts by about 70%

<u>WAYS TO REDUCE SEABIRD BYCATCH</u>

- Mitigation research - leads to technological and operational changes
- Data on bycatch
- Stakeholder acceptance of the problem and solutions
- Training crews in the use of effective strategies
- Management actions
    - Bycatch limits
        - Global
        - Per vessel (e.g., ESA regulations in AK and HI, and CCAMLR regulations for the trawl fishery)
    - Regulations on gear and/or deployment (e.g., CCAMLR, CCSBT, Australia, New Zealand, U.S., Japan, South Africa, and Falklands/Malvinas)
    - Incentive programs - currently utilized in Australia, New Zealand, and Chile

<u>CONCLUSION</u>

- An effective bycatch reduction program requires building a constructive partnership between fishermen, scientists, managers, and non-governmental organizations, including:
    - Reasonable goals
    - Practical approaches
    - Respect
    - Gradual improvement
    - Participation
    - Communication

Acknowledgments

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- Martín Hall - Inter-American Tropical Tuna Association
- Bruce Gourock - Gourock New Zealand
- Ben Sullivan - Falkland Conservation, Falklands/Malvinas Islands
- Hiroshi Minami - National Research Institute of Far Seas Fisheries, Japan
- Eric Gilman - National Audubon Society's Living Oceans Program, US
- Hiroshi Hasegawa - Toho University, Japan

Questions and Discussion

Question: Can you elaborate on the use of incentives?

Response: In Australia and New Zealand, if vessels can demonstrate that they are using bycatch reduction measures (e.g., leaded lines to increase sink rates), they can get relief from other requirements (e.g., restrictions on night setting).

Comment: In the Eastern Tropical Pacific purse seine fishery a big incentive for fishermen was individual vessel limits on dolphin bycatch. This was very successful and could be useful in other fisheries.

Question: Are vessels restricted from discarding hooks under MARPOL requirements?

Response: During processing of the fish, if hooks are not removed from heads they can go overboard with the heads.

Comment: One participant noted that BirdLife International is advertising a competition among fishermen to submit ideas for reducing seabird bycatch that will be ranked in terms of potential and then rewarded.

PLENARY MODERATED DISCUSSION

Session: Bycatch Reduction Research

***Experimental Design*:**
One participant asked Mr. Watson to further discuss caveats associated with target catch and experimental design of the NED experiment. Mr. Watson explained that swordfish loss with squid as bait varied across vessels from 10-60%. Researchers believe standardized restrictions and rapid hauling of gear caused most lost fish; therefore, loss of swordfish was an artifact of the experimental design. During the next year of the experiment, they are considering relaxing certain standardized restrictions (e.g., daylight soak time) to maximize target catch. Another participant inquired whether minimizing daylight was an important factor that should be kept standard across vessels. Mr. Watson explained that experimental treatments and controls will remain the same, just less stringent. A participant noted that the presented results may even be conservative due to these variations and reductions in bycatch may actually be higher than preliminary results indicate.

***Hook Type*:**
A participant inquired whether circle hooks were more difficult to remove from hooked turtles than "J" hooks. Another participant answered that the nature of circle hooks does make them more difficult to remove, however, dehooking devices can be tweaked and customized for particular hook types. Dr. Bolten added that during the experiment in the Azores, they did not have a difficult time removing circle hooks. That experiment did not place requirements on haul time, so hooks may not have been set as deeply in the turtles caught off the Azores. A participant did mention that removing hooks from leatherbacks was especially problematic since they are rarely brought onboard the vessel. Another participant inquired whether mortality was higher for turtles hooked with "J" hooks. Participants agreed that mortality was higher for "J" hooked turtles because there is a higher incidence of "J" hooks catching in the upper jaw, which lies directly below the brain.

Workshop participants discussed which global fleets are currently using circle hooks. The Canadian fleet uses 16/0 circle hooks in an attempt to limit the number of swordfish caught when targeting bigeye tuna. Canada has a swordfish quota that, once met, also limits the bigeye tuna fishery. Costa Rica has utilized circle hooks for the past few years, while use in the U.S. is still experimental. Mr. Watson noted that the 3^{rd} year of the NED experiment will target bigeye to evaluate target catch and non-target catch with various sized circle hooks, including a 20/0 circle hook. Another participant noted that 20/0 circle hooks will hopefully be tested in the Hawaiian longline fishery as well in the near future. One participant noted that the Japanese fleet uses a Japanese style tuna hook, which is an intermediate between a circle hook and a "J" hook. This type of hook was globally predominant for many years. It catches blue shark especially well. The participant suggested that it might work similar to a circle hook if it was offset.

A participant inquired on the status of corrodible gear. Another participant mentioned that a study performed by Maryland Department of Natural Resources found that hooks were not corroding as previously thought. The point of entry on the hook was not exposed and thus did not oxygenate and corrode.

***Timing of interactions*:**
The discussion then shifted to times of highest interaction between gear and turtles. A participant inquired whether fishing at night would reduce interactions with turtles, as it has done with seabirds. Dr. Bolten noted that they did not utilize hook timers in the Azores experiment, so there is no way of knowing when exactly turtles become hooked. In the NED, interactions with loggerheads occur primarily in the daytime whereas interactions with leatherbacks occur at all different times. However, loggerhead interactions may be related to temperature and not time of day. Another participant noted that night setting equals day time hauling; it's a 24 hour process. Lastly, one participant explained that dive depth data on loggerheads illustrates shallow maximum dive depths at night.

SECOND INTERNATIONAL FISHERS FORUM - EXECUTIVE SUMMARY

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Honolulu, HI 96813 USA

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U.S. National Marine Fisheries Service
Pacific Islands Fisheries Science Center
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Longline fisheries accidentally hook and kill seabirds, such as the albatross, by the tens of thousands each year. Finding the solution to this problem is a priority for regional, national and international governments and organizations.

Likewise, sea turtle populations throughout the world have declined greatly over the last century. Some populations have been driven to near extinction. The primary causes of this decline are the direct harvest of nesting females and their eggs; the destruction of nesting and foraging habitat; marine pollution; and the incidental capture of sea turtles in various types of fishing gear, including longline gear.

While work to develop solutions to reduce the bycatch of sea turtles and seabirds by longline gear has begun, fishermen, managers and scientists recognize that these efforts must be enhanced and collaboration must be pursued internationally as these species are highly migratory, inhabiting the waters of many nations during their life cycle.

To further this cause, the Western Pacific Fishery Regional Fishery Management Council hosted the Second International Fishers Forum (IFF2), Nov. 19–22, 2002, in Honolulu.

IFF2 built on the First International Fishers Forum (IFF1) held in Auckland, Nov. 6–1, 2000, organized by the New Zealand Government's Department of Conservation and Ministry of Fisheries, in association with the New Zealand Seafood Industry Council. Many of the world's leading longline fishing fleets were represented at IFF1 to exchange information and develop practical measures to minimize the incidental capture of seabirds in longline fishing operations. Participants agreed that the incidental capture of albatrosses and petrels in longline fisheries was a serious problem that has had significant impacts on the populations of some species over the past 20 years. They recognized the need for ongoing research and development and acknowledged that progress would be determined by their own contributions within their own fishing entities, regions and organizations. In this way each entity, region and organization was to set its own objectives based on its particular expertise and economy.

IFF2 widened the focus of IFF1 to address the accidental bycatch of sea turtles as well as seabirds by longline fishing gear. IFF2 had the following objectives:

- To increase the awareness of fishermen to the incidental longline catch of seabirds and sea turtles that may pose a serious problem to these populations and to the continued operations of longline fishing.
- To promote the development and use of practical and effective seabird and sea turtle management and mitigation measures by longline fishermen.
- To foster and exchange and dissemination of information among fishermen, scientists, resource managers and other interested parties on the use of mitigation measures and the development of coordinated approaches to testing new measures.
- To promote the development and implementation of collaborative mitigation research studies by scientists, fishermen, resource managers and other interested parties.
- To build on IFF1, encouraging continued progress and new participants.

More than two hundred representatives from fishing industries, government agencies, non-governmental organizations and other interested parties from 28 countries in the Atlantic, East and Central Pacific, North Pacific and South Pacific participated in IFF2.

Ambassador Satya N. Nandan, Secretary-General of the International Seabed Authority, delivered the opening remarks, setting ambitious goals for the Forum participants: “The longline fishing industry has been proactive in developing mitigation measures for seabird interactions, e.g., tori poles, blue dyed bait, setting chutes are all ideas that stem from longline fishermen, and were developed with the cooperation of the longline industry,” he noted.. “The same inventiveness now needs to be applied to the problem of reducing longline-turtle interactions. … By taking a proactive role in the development of turtle mitigation technology and strategies longline fisheries will provide an effective rebuttal to more draconian solutions which have been proposed such as outright longline bans or severe constraints on longline fisheries.”

Assisted by professional facilitators, the participants engaged in four days of plenary and breakout sessions focused on eight themes. Some of the sessions included “fishermen only” groups, while others were open to all.

The Seabird Mitigation and Research Session participants generally agreed that existing mitigation practices have positive impacts and the need is not for new technologies but for fine-tuning and broadening the use of existing technologies. They also agreed that improved mitigation results would likely come from better crew training, expanded testing in different regions, new vessel construction and the development of minimum standards. Participants strongly believed that no single mitigation technology was likely to serve as a "silver bullet." Instead, the best results would likely come from developing a "toolbox" consisting of suites or combinations of measures. Ultimately, these solutions would need to be incorporated into the design of new vessels.

The Sea Turtle Mitigation and Research Session participants agreed that the major challenges standing in the way of finding a means to reduce sea turtle–longline bycatch include data needs on the biology of target species and bycatch, effective gear modifications and fishing tactics, research facilitation and dissemination, and industry/public awareness and incentives for action.

The Data Collection Session participants focused on the overarching issues of insufficient data and enduring mistrust between fishermen, on the one hand, and those who collect and use the data, on the other hand. Most participants generally felt that there was ample room for improvement. Several cautioned that it might take some time to overcome the lack of trust that exists between the fishing industry and those responsible for monitoring and regulating it.

The Education/Communication Session participants said that fishermen need broad information on seabirds and marine turtles, such as vulnerability of populations, population trends, how to avoid catching them and how to release them. They said species profiles of marine turtles and seabirds would be useful to fishers, observers and schools and are worth reproducing. They suggested waterproof plastic books or folders, ring binders, or waterproof pocket flipbook as the reproduction format and translations in Spanish, Portuguese, Mandarin, Japanese and English.

The Obstacles, Lessons Learnt and the Way Forward Session participants suggested improving international technical coordination among fishermen, gear manufacturers, biologists and others to produce new enhanced mitigation measures; closing the gap between fishermen and other concerned parties to enable them to work together more effectively and to build coalitions to realize commonly held goals; and better informing fishermen and consumers about the need for reducing incidental seabird and sea turtle bycatch in longline fisheries and of the progress that has been made by some fishermen and fisheries.

The International Agreements/National Approaches Session participants recommended the creation of an International Plan of Action (IPOA) on sea turtles, incorporating sea turtles into existing IPOAs and making international agreements less generalized and more specific. They noted that new ideas on mitigating turtle interactions have to be sold to the fishing industry, and good science is essential to accomplish this. They said fishing gear should include identification marks for the source fishery, as specified in the FAO Code of Conduct. The group agreed that the remote monitoring of fishing fleets by vessel monitoring systems is only really effective for time area closures. They said feedback on research should be a professional courtesy and agreed that a mechanism is needed to assess the socio-economic impacts of measures implemented under international agreements. The group also proposed a list of items to be added to international agreements to improve their efficacy.

The Modeling Session participants participated in hands-on exercises using deterministic (where there is no randomness) and stochastic (where chance plays an essential part in the calculations) models. The industry people found models to be more complex than they had anticipated, but they expressed interest in using them in economic or business type applications. Some managers said the session helped them communicate with modelers or people who used models. The researchers were pleasantly surprised to discover what could be done with simple models, e.g., to convey data needs to those who collect the data.

The Fishermen Incentives Session identified effective incentive instruments to minimize bycatch of seabirds and sea turtles in each represented longline fishery. Participants most commonly expressed an interest in instituting bycatch fee and exemption structures, industry self-policing and eco-labeling.

On the final day, several speakers provided participants with thoughts of encouragement and insightfulness as they prepared to write the Forum's outcomes.

In recounting US efforts to reduce incidental bycatch of sea turtle and seabirds, William T. Hogarth, NOAA Assistant Administrator for Fisheries, said: "One pattern certainly has emerged in these efforts to promote the development and use of practical and effective seabird and sea turtle management measures by longline fishermen: collaboration and an international focus yields the best results."

In a video address, US Sen. Daniel K. Inouye urged participants to "work especially hard to develop the international cooperation necessary for effective management. … One country alone cannot stem the jeopardy to the world's ocean resources; the effort must be international in scope." He proposed a multi-pronged approach that included continuing the collaborative efforts amongst industry experts, scientists and managers started at IFF1 and encouraging governments to support cooperative rather than unilateral approaches, efforts to protect sea turtle nesting grounds and mitigation of the effects of marine debris.

With the thoughts of these and other speakers as background, the participants drafted a Forum Resolution, which contains four action items:

- To request that the Western Pacific Regional Fishery Management Council present the findings of the Forum at the next Session of the Committee of Fisheries of the Food and Agriculture Organization.
- To encourage the FAO to organize an expert consultation with relevant international organizations to develop Guidelines leading to an International Plan

of Action for the Reduction of Sea Turtle Bycatch from Marine Fisheries throughout the world's oceans.

- To invite the Convention on Migratory Species to consider how best to reflect the findings of IFF2 in the further development of existing and planned instruments for the purpose of conserving marine turtles and seabirds on a global scale.
- To encourage the FAO, relevant regional fisheries management organizations and national agencies to collaborate in the implementation and monitoring of the International Plan of Action to reduce incidental catches of seabirds in longline fisheries.

Another concrete outcome of IFF2 was the 65 commitments made by individual participants to a variety of projects to protect sea turtles and seabirds. They included the following actions:

- Share mitigation technologies with different fisheries in different nations.
- Commit to use and test more mitigation strategies and to encourage the same within particular fleets, fisheries and nations.
- Form multi-stakeholder advisory committee to address mitigation, data collection and research needs within particular fisheries.
- Increase involvement of fishermen in the development of new mitigation technologies;
- Secure the participation of more longline fishing nations and fishermen in reducing incidental bycatch of seabirds and sea turtles.
- Create public awareness campaigns regarding the issues being faced and the progress made to date.
- Improve communications between the different stakeholder communities.
- Improve logbooks and other data collection techniques.
- Conduct new research studies (e.g., turtle survivability and mitigation, line weighting studies).
- Develop databases and websites to improve information organization and dissemination and to provide educational materials to all necessary audiences.
- Improve communication and collaboration among agencies around the world that have drafted FAO National Plans of Action in seabirds and mentor other countries that have not yet done so.
- Increase the presence of NGO members on fishing boats.
- Organize further conferences on the topic.

Upon conclusion of IFF2, participants were asked a series of four exit questions. These questions assessed the success of the forum and provided a means to voice concerns or provide recommendations for future meetings. Based on the results of this questionnaire as well as the questionnaire completed during the IFF2 registration period, the following participant observations and recommendations were gleaned.

IFF2 provided participants with education, collaboration and networking opportunities as well as a better understanding and appreciation of regional and international bycatch issues. Participants gained motivation to continue working towards development of bycatch solutions and seemed eager to take home information or institute mitigation methods acquired at the Forum. Overall, this was seen as a positive and successful meeting on many levels, yet it was also widely recognized that work remains to address global awareness and implementation of mitigation measures.

The Forum concluded that there is a need to bring together all the nations that participate in longline fisheries to search for inclusive solutions that allows the fishers, seabirds and sea turtles to survive. The apparent lack of international participation from some major fishing countries, particularly those with distant-water fishing fleets, is a concern. Future organizers should focus on integrating these countries in the Forum process.

Participants also suggested that future Forum breakout sessions be restructured to promote and ensure integration of all stakeholders to facilitate the exchange of ideas, break down cultural barriers between scientists and fishers, and promote transparency. It would have been beneficial for participants to know each other's stakeholder status (fishermen, industry support, academia, research, government, NGO, etc.) and the region/area of the fishermen's operations.

Most important, perhaps, IFF2 concluded that the very active engagement of the fishers was a necessary component for a successful program. They recognized that most of the solutions to bycatch programs have originated with the fishers, so there is a need to develop mechanisms to encourage and channel the creativity of the fishermen.

INTRODUCTION TO BREAKOUT GROUP SESSIONS

Four breakout groups, each with a leader and a rapporteur, were established. Workshop participants were randomly assigned to one of four groups. The groups initially met to discuss and formulate strategies and recommendations for addressing sea turtle bycatch in longline fisheries. After this first session, workshop facilitators met with breakout group leaders to identify commonalities between the four groups. Six overarching themes, or strategies, emerged from these initial discussions: (1) improved data collection; (2) regulatory approaches to fishery management; (3) incentives to participate in the development and implementation of bycatch reduction measures; (4) modifications of gear and fishing practices; (5) modifying, developing, and implementing multi-lateral agreements; and (6) training, outreach, and capacity building.

Breakout groups then reconvened to develop specific recommended action items under each of the six strategies. The action items developed by each breakout group are presented in the following section of these Proceedings. After this second session, workshop facilitators and breakout group leaders identified commonalities between the four groups and synthesized all recommendations into one integrated document.

This integrated document was presented to workshop participants during a plenary session. Participants were asked to prioritize those recommendations they considered critical to reducing interactions between sea turtles and longline fisheries. For each of the six strategies, this ranking exercise categorized action items as “Highest Priority Actions,” “Priority Actions,” and “Actions.” The outcome of this exercise is summarized in the Executive Summary of the Workshop, which is included in the beginning of this document (pg. 1).

Breakout Group 1:
Leader: Alan Bolten
Rapporteur: Jeff Seminoff

Joanna Alfaro
Mario Boza
Juan Carlos Cantu
I-Jiunn Cheng
Jim Cook
Shawn Dick
John Hoey
Luc Laurent
Kim Rivera
Carolyn Robins
Mark Showell
Peter Williams

Breakout Group 2:
Leader: Colin McIff
Rapporteur: Vicki Cornish

Randall Arauz
Rich Brill
Paolo Casale
James Findlay
Rebecca Lewison
Yoshi Matsuzawa
Dae-Yeon Moon
Joel Prado
Barbara Schroeder
Heather Stirratt
John Watson
Patricia Zarate

Breakout Group 3:
Leader: Peter Dutton
Rapporteur: Kristy Long

Alejandro Arrivillaga
Andres Chipollini
Antonio di Natale
Pablo Guerrero
Doug Hykle
Peter Lindgren
Jeff Polovina
Earl Possardt
Gilberto Sales
Gerry Scott
Yonat Swimmer
Dai Xiaojie

Breakout Group 4:
Leader: John Sibert
Rapporteur: Sali Bache

Chris Boggs
Robert Campbell
Alma Dickson
Marydele Donnelly
Martin Hall
Dave Hogan
Dave Kulka
Dimitris Margaritoulis
Helen Martins
Chris Orphanides
Rafael Ramiscal
Cheryl Ryder

ACTION ITEMS DEVELOPED IN BREAKOUT GROUP #1

Strategy 1: IMPROVED DATA COLLECTION AND MONITORING

- Identify data gaps
- Establish minimum standards to data collection for observer programs as well as biological information
- Expand experimental research protocols
- Develop partnerships with other data groups
- Utilize existing networks for distributing data forms
- Develop a website for data standards and dissemination
- Identify funding sources
- Develop monitoring programs

Strategy 2: REGULATORY APPROACHES TO FISHERY MANAGEMENT

- Establish appropriate guidelines within ESA
- Promulgate and implement domestic/national regulations
- Utilize trade and other agreements as well as regional programs to establish fisheries practices
- Establish scientific observer programs as requirements within domestic and international regulations
- Facilitate transfer of data/information into regulations – add to website

Strategy 3: INCENTIVES TO PARTICIPATE IN THE DEVELOPMENT AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

- Consider financial incentives
- Establish CSL to provide funds for park managers, etc.
- Provide gear to encourage better practices
- Establish trade incentives for adopting "turtle safe" practices
- Allocate quotas relative to bycatch and or adoption of mitigation
- Allow access of funds dependent upon compliance of bycatch reduction practice

Strategy 4: MODIFICATIONS TO GEAR AND FISHING TACTICS

- Consider incentives to foster use of gear
- Establish bycatch reduction technology sharing programs to fishers and scientists (e.g., hooks, safe handling and release technologies)
- Develop gear modification for artisanal fisheries
- Give high priority to gear and fishing practices
- Ensure that research continues to ensure that target species yield is remains profitable
- Rapid deployment of successful developments in gear / fisheries practices

- Foster a global environment where experimental fisheries can continue
- Continue gear and fisheries practice research

Strategy 5: MODIFYING DEVELOPING AND IMPLEMENTING MULTI-LATERAL AGREEMENTS

- Encourage countries to modify national reporting standards and/or enter into international data collection agreements
- Ensure that international agreements are able to fulfill mandates, e.g., have necessary funds
- Ensure regional and international agreements recognize target and non-target species
- Request that COFI convene a technical working group to focus on sea turtle bycatch
- Request that ICA require reporting on bycatch from all fisheries
- Develop a standing committee/taskforce (with coordinator) out of this group to ensure that there is continuity into the future
- Identify a successful agreement/framework/model to base future agreements

Strategy 6: TRAINING, OUTREACH , AND CAPACITY BUILDING

- Identify graduate students to build national scientific capacity
    - Graduate students
    - Future leaders
    - NGOs
- Identify and train future community leaders
- Identify funding sources and NGOs
- Website
- Develop and standardize observer training programs
- Identify funding source
- Conduct dockside or field-based workshops for training crew, captains, owners
- Develop public relation/education packages using multi-media approaches
- Introduce sea turtle conservation and bycatch issues in Fisher courses
- Develop "lobbying" documents for national and international programs for decision makers and general public
- Introduce issue of bycatch to NGOs

ACTION ITEMS DEVELOPED IN BREAKOUT GROUP # 2

Strategy 1: IMPROVED DATA COLLECTION AND MONITORING

- Fully characterize longline fisheries to target where monitoring programs would be most effective
- Target areas with apparent data gaps (and confirm that these are indeed data gaps and not just data that has yet to be mined)
- Fund and implement monitoring programs in developing countries (pilot/small scale observer programs and/or dockside interviews)
- Encourage RFMOs and countries to build existing knowledge on longline fishing effort, fishing strategies, and to integrate collection of sea turtle bycatch data into broader data collection strategies
- Encourage RFMOs and countries to build existing knowledge on longline bycatch of sea turtles
- Establish regional and international forum for sharing information on turtle bycatch (and other non-target bycatch) and monitoring methodologies in longline fisheries, with emphasis on standardizing data collections or identifying minimum data elements

<u>Data that need to be collected</u>:

- Gear: depth of leaders, depth of float lines, hooks between hooks, hook type and size
- Fishing tactics: time of day, bait used, target species
- Focus on measurable characteristics

Strategy 2: REGULATORY APPROACHES TO FISHERIES MANAGEMENT

- Reduce or cap fishing effort worldwide, working through RFMOs and cooperative organizations, with an emphasis on areas where sea turtle bycatch is highest
  - Consider time/area closures, or “move-on” requirements where data support
- Reduce subsidies of longline fisheries
- Revise regulations such that they do not hinder use of best available approach to handling hooked turtles
- Consider existing/best available research and information regarding gear modifications when developing regulations for longline fisheries

Strategy 3: INCENTIVES TO PARTICIPATE IN THE DEVELOPMENT AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

- Involve industry in discussions at earliest point possible
- Encourage incentives on regional and international scale
  - Regional: competition, release rewards, captain/crew certification
  - International: eco-labeling and market-based incentives

Strategy 4: MODIFICATIONS TO GEAR AND FISHING TACTICS

- Encourage funding for demonstration/testing to build on existing gear research (i.e., circle hooks) in other fisheries
- Coordinate networks for discussion of bycatch gear modification efforts
- Promote sharing of information between gear engineers, gear suppliers, industry, and scientists on effectiveness of certain gear in reducing bycatch and impact on target catch levels, including results of gear experiments
- Encourage expansion, refinement, and funding of research and testing on hook design, branch line materials, bait type and threading technique, deep sets
- Increase research on post-hooking mortality
- Encourage research on attractiveness of gear, especially with respect to differences between species

Promising areas of research:
- Reduce daylight soak time for shallow set gear (loggerheads)
- Leaders longer than float line
- Leaded swivels on leaders
- Circle hooks
- Turtle handling and gear removal (dehookers, line cutters, etc.)
- Mackerel baits - 500g for swordfish operations
- Real time communication between fleet to avoid areas of high turtle densities

Strategy 5: MODIFYING, DEVELOPING, AND IMPLEMENTING MULTILATERAL AGREEMENTS

- Free trade agreements should promote independent "turtle-safe" certification programs
- Integrate turtle bycatch issues into existing organization discussions to promote reduction of sea turtle bycatch
- Call for formal government to government meeting on sea turtle bycatch (and to discuss and support IFF2 resolution)
- Special attention should be given to developing countries when developing agreements
- Investigate legal framework for bycatch reduction on the high seas
- Continue efforts to address IUU fishing - focus on positive effect on sea turtle bycatch
- Actively engage fishing industry organizations in development of cooperative agreements (i.e., International Coalition of Fishing Organizations)

Strategy 6: TRAINING, OUTREACH, AND CAPACITY BUILDING

- Convene subsequent meetings of IFF2 and expand participation to all ocean basins
- Develop outreach materials in multiple languages for public, industry, and government officials
    - Integrate longline issues in overall sea turtle conservation materials
    - Increase awareness on bycatch in general
    - Identify how people can help (e.g., mitigation strategies and handling techniques)
    - Incorporate public relations expertise (perhaps from NGOs)
- Provide necessary gear (i.e., de-hooking devices) to industry, and/or information on how fishermen can get gear, include handling guidelines
- Promote local exchange of information
- Promote cooperative research programs and scholarships for bycatch reduction research
- Build capacity for development of legal frameworks
- Highlight the important role that NGOs play with respect to outreach and funding
- Support intra-governmental organization and communication

ACTION ITEMS DEVELOPED IN BREAKOUT GROUP #3

Strategy 1: IMPROVED DATA COLLECTION AND MONITORING

- Re-analyze existing data
  - Mediterranean data sets (e.g., mass movements, hot spots, hook type, CPUE)
  - Northeast Distant Area (NED)
  - Pacific
  - Availability and data from Japanese experiments
- New experiment in the NED with hook timers and sensors
  - Coordinate among regions and experiments
  - Take already developed research plans and undertake comparable experiments in other regions (e.g., Gulf of Mexico, Mediterranean, South Pacific)
- Identify and fill in existing gaps
  - Indian Ocean - IOTC
  - West Africa – ICCAT
  - South America – IATTC, ICCAT
  - Southeast Asia – SEAFDEC
  - Pacific - MHLC
- Standardize bycatch data collection among different fisheries (including artisanal fisheries), minimum basic collection, establish format or disseminate existing formats. Refer to established protocols. Antonio Di Natale volunteered to provide an existing form, which can likely be adapted.
  - Species
  - Sex
  - Size
  - Condition of the animal
  - Sample
  - Gear type
- Establish a website for the Workshop and identify organization to follow up with compilation and dissemination of standard data form/collection
- Organize regular workshops either annually or biannually to update disseminate information and results
  - Identify units of management – artisanal, coastal, high seas, etc.
  - Characterize different fisheries
  - Compile information from the different fisheries to better define where data exist for each of the types
- Collect new data using satellite telemetry on turtle corridors, and longer term studies to find mortality

Strategy 2: REGULATORY APPROACHES TO FISHERY MANAGEMENT

- Turtle interaction quotas per boat – immediately in the U.S.
  - Species specific - leatherbacks and loggerheads are more critical in the Pacific
  - Set by agreement
- Minimum observer coverage
- Require effective/affordable treatment to be permitted to fish (that is easily enforceable), (e.g., gear type that catches fish not turtles for the long term)
- Develop new approaches for real-time spatial management applied to all fleets
  - Identify high densities of turtles, migratory corridors ("hot spot" approach)
  - Critical habitat, dynamic
  - Utilize satellite telemetry and remote sensing
- Implement VMS across fleets to enforce real-time spatial management
  - Address VMS within RFMOs
- Undo current Spanish regulation that "J" hooks of a certain size must be used for all longline fishing (regulation prevents the Spanish from even testing other hook types)

Strategy 3: INCENTIVES TO PARTICIPATE IN THE DEVELOPMENT AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

- Establish a program for (Azores, Chilean, and Brazilian swordfish fisheries) within an international framework through governments and industry to:
  - Provide large circle hooks to Azorean fishers (based on latest research)
  - Establish a training program for recipients of these hooks on treatment techniques (e.g., bait type)
  - Technical assistance with experimental design and data analysis and evaluation
- Approach Marine Stewardship Council about developing criteria for an experimental certification program for the longline fishery (i.e., a country has an observer program, is using the most "turtle-friendly" gear and fishing practices, data collection programs, research collaboration, and implementation of mitigation measures.) This would need to be a dynamic program based on current state of knowledge.

Strategy 4: MODIFICATION TO GEAR AND FISHING TACTICS

- Communicate results of the NED and Azores experiments to other regions via ICCAT and NAFO,
- Direct additional and immediate research to fine tune:
  - Effects of circle hooks on target species (i.e., improve catchability)
  - Improve baiting techniques
  - Experiment with weighted leaders to reduce leatherback entanglement
  - Repellents – shark scent or profile
- Address issue of how those new methods affect bycatch
- Promote use of de-hookers, line cutters, resuscitation techniques, best practices to minimize mortality [include in package under incentives]

Strategy 5: MODIFYING, DEVELOPING, AND IMPLEMENTING MULTI-LATERAL AGREEMENTS

- Propose a government to government meeting, possibly a technical consultation under FAO then follow up with RFMOs, to move forward with the actions identified at this Workshop
- Encourage CPPS to conduct a regional meeting and develop sea turtle action plans
- Introduce specific ideas from this meeting into regional conservation plans
    - IAC
    - IOSEA
    - African MOU
    - CPPS
- Introduce language on longline sea turtle bycatch into a UN General Assembly resolution

Strategy 6: TRAINING, OUTREACH, AND CAPACITY BUILDING

- Establish a training task force
    - Target industry trade shows (e.g., Spain in summer 2003; China in fall 2003; and annual FishExpo in Seattle USA)
    - Visit country and establish in-country capacity to train and disseminate information to decision makers (e.g., fisheries and resource managers) and industry
- Develop training/information kits (on cd – easier to mail, reproduce, etc.)
    - Explain problems, solutions, best practices
    - Tailored to appropriate audiences
    - Updated with new information as available

ACTION ITEMS DEVELOPED IN BREAKOUT GROUP #4

Strategy 1: IMPROVED DATA COLLECTION AND MONITORING

- Require and provide funds for monitoring of artisanal fisheries, beginning with pilot programs (e.g., dockside interviews and small observer programs)
- Provide funds for monitoring in developing countries, beginning with pilot programs (e.g., dockside interviews and small observer programs)
- Fully characterize fisheries to develop monitoring programs
- Emphasize confirming data gaps and focus data collection and monitoring in these areas
- Encourage RFMOs and nations to collect, report, and share bycatch data
- Integrate effort and bycatch data into programs
- Collect, report, and share effort data (i.e., countries and RFMOs)
- Establish regional and international fora for sharing and standardizing bycatch data collection, focusing on sea turtles, but including other non-target bycatch
- Increase research on mortality of bycatch species

Strategy 2: REGULATORY APPROACHES TO FISHERY MANAGEMENT

- Reduce or cap fishing effort worldwide by working through RFMOs and cooperative organizations
- Reduce subsidies to longline fisheries
- Emphasize effort reductions in areas where sea turtle bycatch is highest
  - Consider time and area closures
- Revise regulations to allow employment of best available handling and de-hooking practices
- Consider existing and best available information regarding gear modifications to reduce bycatch, including real time data

Strategy 3: INCENTIVES TO PARTICIPATE IN THE DEVELOPMENT AND IMPLEMENTATION OF BYCATCH REDUCTION MEASURES

- Involve industry in discussion at earliest point possible
- Encourage competition of ideas (local), release rewards (local), eco-labeling (global), market-based incentives (global), and captain and crew certification
- Provide monetary support for incentives

Strategy 4: MODIFICATION TO GEAR AND FISHING TACTICS

- Encourage funding and testing of projects while building on existing work
  - Demonstrate in countries
- Coordinate bycatch gear modification efforts; reduce duplication

- Promote sharing of information on gear experiments by forming small subgroups that include industry, gear experts, gear suppliers, etc.
  - Include target catch numbers
- Encourage expansion, funding, and refinement of research regarding hook design, bait, moving branch lines, set depth, etc.
- Encourage gear research for alternatives to currently employed branch line material
- Encourage gear modifications that focus on reducing bycatch through changing turtle behavior (i.e., deterrents), while noting differences between species

Strategy 5: MODIFYING, DEVELOPING, AND IMPLEMENTING MULTI-LATERAL AGREEMENTS

- Investigate and establish legal framework for bycatch reduction on high seas
- Free trade agreement should promote independent certification programs
- Integrate sea turtle issues into existing organization discussions to promote reduction of bycatch
- Support IFF2 resolution that calls for a formal government to government meeting
- Give special attention to developing countries when developing and implementing new measures
- Continue efforts to address IUU fishing, focusing on its positive effect on sea turtle bycatch
- Actively engage industry and government cooperative agreements, such as an International Coalition of Fishing Organizations

Strategy 6: TRAINING, OUTREACH, AND CAPACITY BUILDING

- Build capacity through regulatory frameworks
- Expand IFF to all ocean basins and convene subsequent meetings
- Increase awareness by developing outreach and educational materials for public, industry, and government officials in multiple languages that:
  - Incorporate public relations information
  - Describe interactions with the longline fishery
  - Describe status of fishery
  - Highlight sea turtle conservation issues (e.g., threats on nesting beaches, etc.)
  - Integrate turtle conservation with ways to help, (i.e., mitigation strategies, handling guidelines, etc.)
- Disseminate information on how to obtain tools (e.g., de-hooking devices) and actual tools to interested parties
- Promote and develop small-scale exchange programs (e.g., human resources)
- Support cooperative research programs and scholarships
- Highlight the importance of NGOs regarding outreach, funding, etc.
- Support intra-governmental organization communication

APPENDIX - LIST OF BACKGROUND MATERIALS PROVIDED TO PARTICIPANTS

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