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11

Minimizing Bycatch of Sensitive Species Groups in Marine Capture Fisheries: Lessons from Tuna Fisheries

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11.1. INTRODUCTION

11.1.1. Ecological, Economic, and Social Issues Related to Fisheries Bycatch

Bycatch in marine capture fisheries is the retained catch of nontargeted but commercially viable species (referred to as "incidental catch") plus all discards (Food and Agriculture Organization of the United Nations [FAO] 2005).[1] It is an increasingly prominent international issue, raising ecological concerns, as some bycatch species of cetaceans (whales, dolphins, and porpoises), seabirds, sea turtles, elasmobranchs (sharks, skates, and rays), and other fish species are particularly vulnerable to overexploitation and slow to recover from large population declines (FAO 1999a, 1999b, in press; Fowler et al. 2005; Gales 1998; Gilman et al. 2005, 2006a, 2006c, 2008; Lutz and Musick 1997). Bycatch can alter biodiversity and ecosystem functions by removing top predators and prey species at unsustainable levels (Myers et al. 2007). It also alters foraging behavior of species that learn to take advantage of discards. Economic effects of bycatch on fisheries include loss of bait, reduced availability of baited hooks when they are occupied with unwanted bycatch species, and concomitant reduced catch of marketable species; the imposition of a range of restrictions, closed areas, embargos, and possible closures; allocation among fisheries, where bycatch in one fishery reduces target catch in another, and bycatch of juvenile and undersized individuals of a commercial species can adversely affect future catch levels (Brothers et al. 1999; Hall et al. 2000). Discarded bycatch raises a social issue over waste: From 1992 to 2001 an average of 7.3 million metric tons of fish were annually discarded, representing 8 percent of the world catch (FAO 2005).

Prominent bycatch issues include dolphins and porpoises in purse seine fisheries and driftnets; fish discards in shrimp trawl fisheries; and seabird, sea turtle, marine mammal, and shark bycatch in longline, purse seine, gillnet, and trawl fisheries (FAO 1999a, 1999b, 2005, in press; Hall et al. 2000). In commercial tuna fisheries, the incidental bycatch of sensitive species groups (seabirds, sea turtles, marine mammals, and sharks) and bycatch of juvenile and undersized tunas are allocation and conservation issues. In addition to problematic bycatch, overexploitation and illegal, unreported, and unregulated (IUU) fishing, which complicates bycatch management, are additional conservation issues facing the management of tuna fisheries. This chapter employs examples of bycatch in commercial tuna fisheries to describe (1) the range of options to reduce bycatch, (2) principles and approaches to successfully introduce effective bycatch reduction measures, and (3) initiatives taken by intergovernmental organizations, the fishing industry, and retailers to address bycatch. Changes needed to improve the sustainability of tuna production are recommended.

11.1.2. Commercial Tuna Fisheries

Purse seine, pelagic longline, and pole-and-line fisheries are the primary commercial fishing methods for catching tunas. Large longline vessels generally catch older age classes of bigeye and bluefin tunas for the sashimi market, and some longline fleets target albacore for canning (figure 11.1). Purse seine vessels catch younger age classes of target skipjack and yellowfin and incidental bigeye tunas for canning (a very small volume is used for tuna ranching) (Majkowski 2007) (figure 11.2). Like purse seiners, pole-and-line vessels catch fish close to the surface, catching mostly skipjack and small/juvenile yellowfin, albacore, and bluefin, primarily for canning (Majkowski 2007) (figures 11.3 and 11.4).

Tuna products are an important food source and global commodity. They are the third most important seafood commodity traded in value terms (FAO 2007). The export value of 2004 internationally traded tuna products was US$6.2 billion ($10^9$), 8.7 percent of total global fish trade (FAO 2007). In 2005, 82 percent of world tuna was consumed as canned product, and 18 percent as fresh product (including as sashimi). Japan consumed 78 percent of the fresh tuna. In 2004, canned tuna consumption was highest in the European Union, followed by the United States, combined accounting for 83 percent of the total global consumption of canned tuna.

Demand for both canned and fresh tuna has been rapidly and steadily increasing: the reported landings of the principal market species of tunas increased from less than 0.2 million metric tons in the early 1950s to a peak of 4.3 million metric tons in 2003, largely due to increased catch of tropical tunas (yellowfin and skipjack) by purse seiners (Majkowski 2007) (figure 11.5). Japan, Taiwan, Indonesia, the Philippines, and Spain accounted for half of 2004 reported landings (Majkowski 2007).

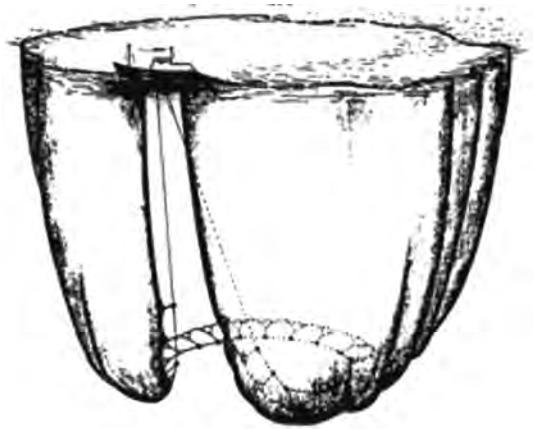

FIGURE 11.2 Deployed purse seine. A purse seine is made of a long wall of netting framed with float line and lead line, with purse rings hanging from the lower edge of the gear, through which runs a purse line made from steel wire or rope, which allows the pursing of the net. Purse seine nets can be up to 1.5 km long and 150 m deep. (Courtesy FAO)

Despite their high fecundity and wide distribution, of the 20 tuna stocks for which the status is known, at least five are "overfished," meaning their biomass levels are below maximum sustainable yield (MSY) or other biological threshold. "Overfishing" is occurring for at least an additional four stocks, meaning the fishing mortality rate is higher than that which produces MSY or other threshold (Bayliff et al. 2005; Majkowski

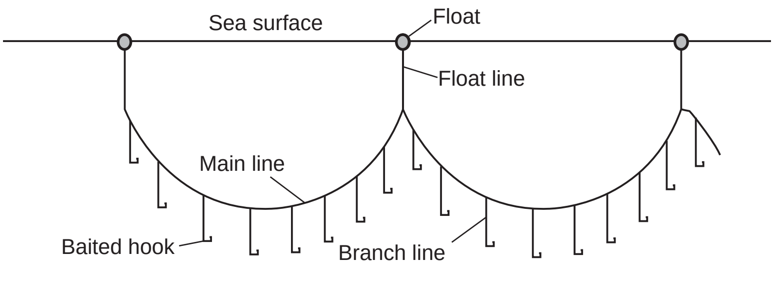

FIGURE 11.1 Basic configuration of a section (two baskets) of pelagic longline gear. Gear is suspended from line drifting freely in the pelagic environment, at depths anywhere from the sea surface to 400 m into the thermocline. Lines can be up to 100 km long and carry up to 3,500 baited hooks. Lengths, materials, design, and methods of setting and hauling vary among fisheries and among vessels in a fishery. (Courtesy E. Gilman)

FIGURE 11.3 Pole-and-line vessel fishing for tuna. (Courtesy U.S. NOAA Fisheries photo library)

2007). Increased purse seine catches of skipjack stocks that are only moderately exploited might be sustainable if gear is restricted to being deployed only on free-swimming skipjack schools. Increased longline and pole-and-line catches of moderately exploited albacore stocks might also be sustainable.

11.2. BYCATCH PROBLEMS IN TUNA FISHERIES

Table 11.1 summarizes problems with bycatch of sea turtles, seabirds, marine mammals, sharks, and juvenile and undersized tunas in pelagic longline and purse seine fisheries. There are extremely low bycatch levels in pole-and-line fisheries, where bycatch that does occur consists of juvenile kawakawa tuna, frigate mackerel, mahi mahi, and rainbow runner. Discards are believed to have high postrelease survival rates due to the use of barbless hooks and flick-off practices (in which crew remove unwanted hooked fish by using a quick jerking motion).

11.3. MEASURES TO REDUCE BYCATCH AND MORTALITY

Table 11.2 summarizes general categories of strategies to reduce unwanted bycatch and mortality in marine capture fisheries. Table 11.3 summarizes the state of

FIGURE 11.4 Longline-caught bigeye and yellowfin tunas for sale at the Honolulu fish auction. (Courtesy Western Pacific Fishery Management Council)

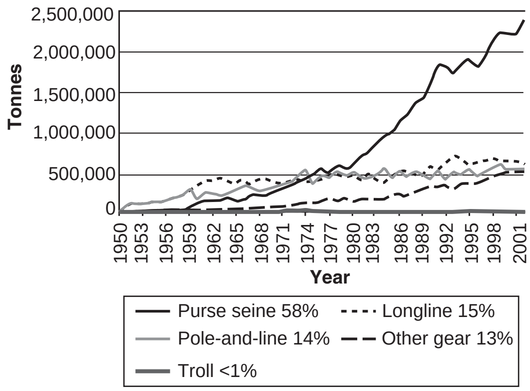

FIGURE 11.5 Trends in weight of world reported landings of principal market species of tunas by fishing gear type. (Modified from Bayliff et al. 2005)

knowledge for reducing bycatch in pelagic longline and purse seine fisheries employing changes in fishing gear or methods. Where progress is lacking, research and development priorities are identified. Figures 11.7–11.9 provide examples of methods to reduce seabird and sea turtle interactions in longline fisheries and dolphin mortality in purse seine fisheries.

Some pelagic longline fisheries have problematic bycatch of seabirds, sea turtles, sharks, and toothed whales. Some purse seine fisheries have problematic bycatch of juvenile and undersized tunas, dolphins, sharks, sea turtles, and whales. Of these, there has been progress in identifying effective bycatch reduction methods only for seabirds and sea turtles on longlines and direct mortality of dolphins in purse seines.

Several principles and approaches require consideration when developing measures to reduce bycatch through changes in fishing gear and methods:

- Fishery-specific solutions: Solutions to bycatch problems may be fishery specific. For instance, while an underwater setting chute has been shown to be very effective at avoiding seabird captures in the Hawaii pelagic longline fleet (Gilman et al. 2003), trials in Australia have been less promising, likely due to the seabird species' complex and behavioral interactions, the weighting design, and the use of live bait (Brothers et al. 2000).

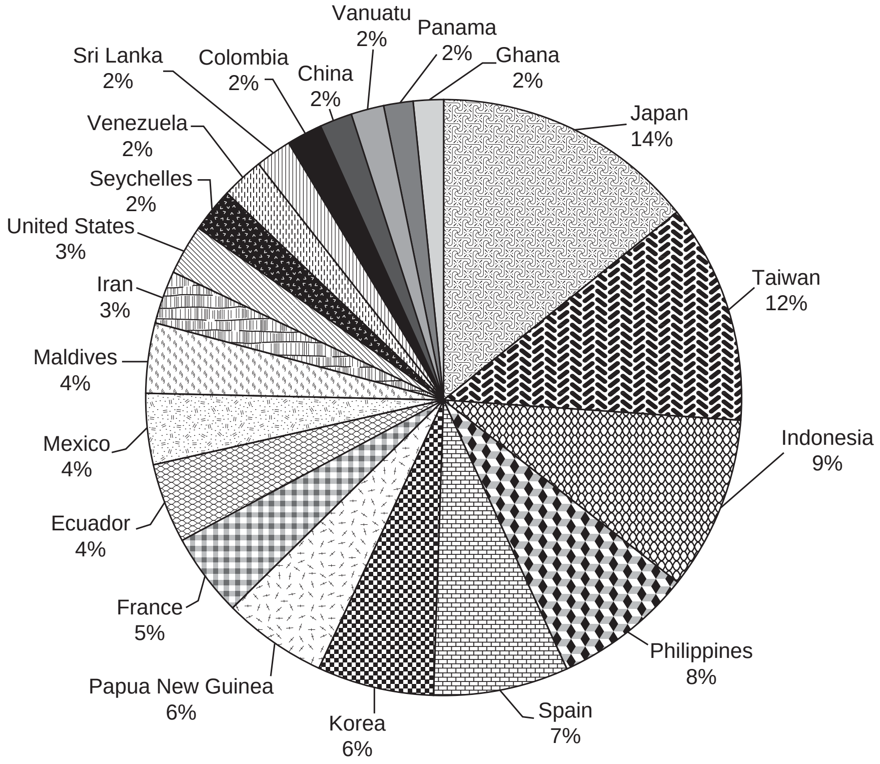

FIGURE 11.6 Contributions to global tuna reported landings, 2004. (Data from Majkowski 2007)

TABLE 11.1 Bycatch problems in pelagic longline and purse seine fisheries

Species Group	Pelagic Longline	Purse Seine
Seabirds	Problematic primarily in higher latitudes; represents the largest threat to most albatross and large petrel species (Gales 1998; Brothers et al. 1999; Gilman et al. 2005)	Not problematic.
Sea turtles	Problematic primarily in the tropics and subtropics; one of numerous anthropogenic threats (Gilman et al. 2006c; FAO in press)	Sea turtles can become entangled in fish-aggregating devices (FADs) and can be caught in the pursed net (Hall et al. 2000; Molony 2005; Romanov 2002). Turtles are typically encountered alive in the net and are released (FAO in press). Sets on FADs and logs result in higher turtle catch rates than do dolphin-associated and unassociated (free-swimming tuna school) sets (Hall 1998; Hall et al. 2000; Safina 2001; Molony 2005).
Sharks	A large proportion of the total catch in some fisheries; can be a target, incidental bycatch, or discarded bycatch (Gilman et al. 2008); there has been increasing concern about the status of some shark stocks, the sustainability of their exploitation, and ecosystem-level effects from shark population declines (FAO 1999b; Myers et al. 2007)	Purse seine fisheries can have high shark bycatch (Hall et al. 2000; Romanov 2002). Sets on FADs and logs result in higher shark catch rates than do dolphin-associated and unassociated sets (Hall 1998; Hall et al. 2000; Molony 2005; Safina 2001).
Marine mammals	Occasionally result in entanglement and hooking of cetaceans, causing injury and mortality (e.g., Forney 2004); fishers may harass and kill cetaceans to try to prevent depredation (removal of hooked fish and bait) and gear damage; isolated (e.g., island-associated) cetacean populations may be most at risk	There has been substantial success in achieving 98% reductions in direct dolphin mortality in purse seine fisheries in the eastern Pacific Ocean (Hall 1998; IATTC 2007a). Dolphin populations have not recovered as anticipated, perhaps because the stress from having purse sets made on them causes miscarriages or separation and loss of calves (Archer et al. 2004; Edwards 2006). Purse seining in other areas typically does not involve setting around dolphins. Purse seine vessels occasionally set on whale-associated tuna schools, which can result in injury and mortality of whales (Molony 2005; Romanov 2002).
Juvenile and undersized tunas	Not problematic (might be higher at seamounts)	Restrictions on setting on dolphin schools resulted in a shift to setting on FADs and logs, where the catch rates of juvenile and undersized tunas and unmarketable species of fish (e.g., mahi mahi, sharks) are higher than in unassociated sets (Romanov 2002; Secretariat of the Pacific Community 2006).

TABLE 11.2 Methods to reduce unwanted bycatch and injury in marine capture fisheries

Method	Description
Modifications to fishing gear and methods	Gear technology and altered fishing methods can reduce bycatch (table 11.3).
Input and output controls	Input controls include limiting the amount of fishing effort or capacity (limiting vessel numbers of a specified size, prohibiting new entrants, instituting buy-back schemes). Output controls include limiting catch through, e.g., total allowable catch, or quotas of target, incidental or discarded bycatch species. For instance, purse seine vessels of nations participating in the IATTC's Tuna-Dolphin Program receive individual vessel dolphin bycatch limits (Hall 1998).
Compensatory mitigation	Individual vessels or a fisheries association could meet bycatch mitigation requirements through compensation to a public or private organization to conduct conservation projects to address other anthropogenic sources of mortality. Management authorities could create a fee and exemption structure for the bycatch of sensitive species, similar to a "polluter pays" system. For instance, governments could reduce or withhold subsidies, charge a higher permit or license fee, or use a higher tax rate if bycatch thresholds are exceeded. Alternatively, the fee structure can provide a positive incentive, where a higher subsidy, lower permit or license fee, or lower taxes apply when bycatch standards are met. Compensatory mitigation programs likely require 100% observer coverage, a substantial limitation. Problems with lack of performance of compensatory mitigation activities and off-site and out-of-kind mitigation could occur when this method, a long-standing practice in U.S. wetlands management (Environmental Law Institute 2006), is applied to fisheries bycatch (e.g., conducting conservation activities at a nesting colony not part of the population interacting with the fishery, or conserving different age classes than affected by the fishery). The concept holds promise if used to complement and not detract from actions to first avoid and minimize bycatch.
Marine protected areas	Spatial and temporal restrictions of fishing, especially in locations and during periods of high concentration of bycatch species groups, can contribute to reducing fisheries bycatch. Establishing protected areas containing seabird or sea turtle nesting colonies and adjacent waters is potentially an expedient strategy. Seasonal closures might also be able to contribute to reversing and preventing the overexploitation of tuna stocks, such as through closures in equatorial waters during the period of peak bigeye and yellowfin tuna spawning. The establishment of a representative system of protected area networks on the high seas also holds promise. However, this will require extensive and dynamic boundaries, defined, in part, by the location of large-scale oceanographic features and short-lived hydrographic features, and would require extensive buffers (e.g., Hyrenbach et al. 2000). Extensive time will be required to resolve legal complications with international treaties, to achieve international consensus and political will, and to acquire requisite extensive resources for enforcement.
Fleet communication	Fleet communication programs can report real-time observations of temporally and spatially unpredictable bycatch hotspots to be avoided by vessels in a fleet (Gilman et al. 2006b). Fleet communication may be appropriate in fisheries where there are strong economic incentives to reduce bycatch, interactions with bycatch species are rare events, and adequate onboard observer coverage exists.
Industry self-policing	Self-policing uses peer pressure from within the industry to criticize bad actors and acknowledge good actors (e.g., Fitzgerald et al. 2004). A fishing industry can create a program where information for individual vessel bycatch levels, compliance with relevant regulations, and other relevant information is made available to the entire industry. This is especially effective where regulations contain industrywide penalties if bycatch rates or caps are exceeded.

(*continued*)

TABLE 11.2 Continued

Method	Description
Handling and release practices	There has been substantial progress in identifying best practices for handling and releasing seabirds and sea turtles caught in longline gear. There are guidelines for implementing backing-down and hand-rescue procedures to release dolphins from purse seines.
Changing gear	It may be commercially viable to introduce alternative fishing methods that result in a lower bycatch to target catch ratio than the previously employed method.

TABLE 11.3 State of knowledge for bycatch reduction in pelagic longline and purse seine tuna fisheries, and research and development priorities

Bycatch Species Group	Pelagic Longline	Purse Seine
Seabirds	Several effective methods, including night setting, tori line, underwater setting devices, side setting, branch line weighting, and blue-dyed bait (Brothers et al. 1999; Gilman et al. 2003, 2005, 2007a)	Not problematic
Sea turtles	Wide circle hook with ≤100 offset and large fish bait (Gilman et al. 2006c; FAO in press); invest in research on deeper setting, alternative hook designs, artificial bait, baiting techniques and deterrents (Gilman et al. 2006c; FAO in press)	Invest in research on modified FAD designs (e.g., Molina et al. 2005); avoid encircling turtles, monitor FADs and release any entangled sea turtles, recover FADs when not in use (FAO in press); restrict setting on FADs, logs, and other debris
Sharks	Fish instead of squid for bait, prohibit wire leaders, avoid hotspots, set deeper, move when shark interaction rates are high (FAO in press; Gilman et al. 2008; Ward et al. 2007); invest in research on shark repellents (Stoner and Kaimmer 2008)	Avoid hotspots; restrict setting on FADs, logs, other debris, and whales; invest in research on shark repellents for deployment on FADs (Stoner and Kaimmer 2008)
Marine mammals	Avoid hotspots, fleet communication (Gilman et al. 2006a, 2006b); invest in research on deterrents and echolocation disruption (Mooney et al. 2008)	Medina panel, backing down, deploy rescuers (Hall 1998); restrict setting on marine mammals
Juvenile and undersized tunas	Not problematic	Invest in research on sorting grids (Nelson 2007); restrict setting on FADs

- Industry direct involvement in research and development: Fishers have a large repository of knowledge, which can be tapped to contribute to finding effective and practical bycatch solutions. Several bycatch reduction methods were developed by fishermen, including the bird-scaring tori line for longlining, and technical methods to reduce dolphin mortality for eastern Pacific purse seining (Hall et al. 2000). Furthermore, participation of fishers can result in industry developing a sense of ownership for bycatch reduction methods.
- Commercial viability: Given the state of fisheries management frameworks, including limited resources for monitoring, control, and surveillance, methods shown to be effective in research experiments at reducing bycatch may not be employed as prescribed or at all by fishers if they are not convenient and economically viable or, better yet, provide operational and economic benefits. Identifying commercially viable bycatch solutions can maximize industry employment. For instance, in some studies, use of circle hooks and fish bait to avoid turtles increased catch rates of some target species (Gilman et al. 2006c), and side setting to avoid seabirds resulted in operational benefits (Gilman et al. 2007a).

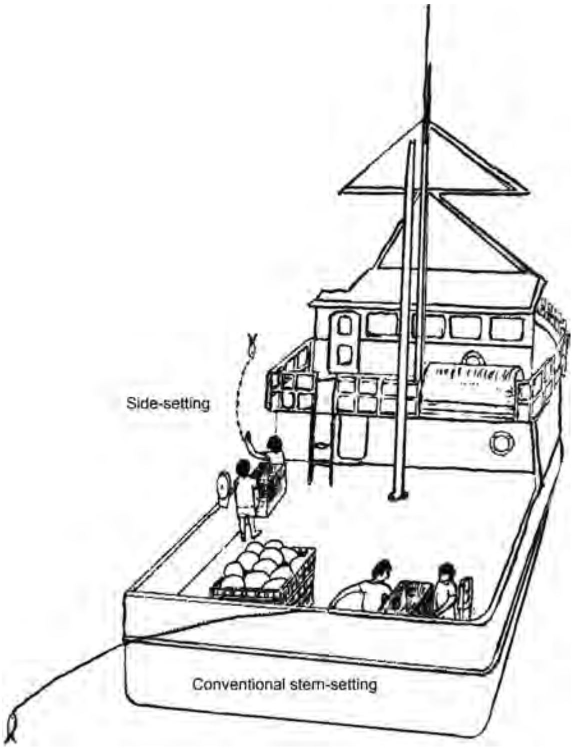

FIGURE 11.7 A seabird avoidance method called "side setting," employed in the Hawaii longline fleet, where gear is set from the side of the vessel rather than the conventional position at the stern (Gilman et al. 2007a), is one of several effective methods to reduce seabird capture in pelagic longline fisheries. (Illustration by Nigel Brothers)

- Consideration of effects on multiple species groups: It is important to identify any conflicts as well as mutual benefits of bycatch reduction strategies amongst species groups. For instance, as discussed previously, efforts to protect eastern Pacific dolphins resulted in increased fishing on fish-aggregating devices (FADs), free-floating or anchored structures constructed and deployed by fishermen to attract schools of fish, which increased bycatch of juvenile and undersized tunas, sharks, dolphin fish, sea turtles, and marine mammals (Hall 1998; Molony 2005; Secretariat of the Pacific Community 2006). Setting longlines at night to protect albatrosses and other diurnal foraging seabirds has led to higher bycatch of nocturnal white-chinned petrels (Weimerskirch et al. 1999). Use of wider circle hooks and fish bait to reduce turtle bycatch rates and mortality in pelagic longline fisheries also reduces bycatch of sharks (Gilman et al. 2006c, 2007c) and seabirds (International Commission for the Conservation of Atlantic Tunas 2007).

11.4. INITIATIVES BY INTERGOVERNMENTAL ORGANIZATIONS, FISHING INDUSTRY, AND RETAILERS AND BUYERS

11.4.1. Regional Fisheries Management Organizations

There has been limited progress in reducing most bycatch problems in longline and purse seine fisheries. The two areas where there has been progress (seabirds on longlines, dolphins in purse seines) may require improvements. Three regional fisheries management organizations (RFMOs) have adopted



FIGURE 11.8 Use of wider circle-shaped hooks and fish bait, instead of narrower J and tuna hooks and squid bait, are methods in use to reduce sea turtle catch and injury in pelagic longline fisheries. (Photo of hooks, E. Gilman; photos courtesy of U.S. National Marine Fisheries Service Southeast Fisheries Science Center)

FIGURE 11.9 Purse seine vessel employing backdown maneuver to allow a school of dolphins to escape. The end of the net farthest from the vessel is lowered beneath the sea surface and passed below the dolphins. A crew member on a raft is assisting with the release of the dolphins. A Medina panel (not visible) is used. A Medina panel is a section of fine mesh netting sewn into the purse seine net to surround the apex of the backdown area where porpoises are most likely to come into contact with and become entangled in the net. (Courtesy of the IATTC)

legally binding measures requiring the employment of seabird avoidance methods: the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), Indian Ocean Tuna Commission (IOTC), and the Western and Central Pacific Fisheries Commission (WCPFC) (Gilman et al. 2007b). The areas where these measures are required may be insufficient in covering higher latitude areas where seabird interactions have been observed to be problematic (Gilman et al. 2007b). Furthermore, WCPFC does not require vessels <24 m in length to employ seabird avoidance measures in areas north of 230°N latitude, but high seabird bycatch rates have been documented by vessels in this size category in this area (e.g., Gilman and Kobayashi 2008). Inadequate observer coverage prevents determining compliance with these international seabird conservation measures.

In purse seine fisheries, vessels operating in the eastern Pacific Ocean of nations that are contracting parties to the Agreement on the International Dolphin Conservation Program (AIDCP), a legally binding multilateral agreement administered by the Inter-American Tropical Tuna Commission (IATTC), receive annual, individual vessel dolphin mortality limits. There is an annual cap of 5,000 total dolphin mortalities in the fishery, as well as annual mortality caps for individual dolphin stocks, established at 0.1 percent of each stock's minimum estimated abundance (IATTC 2007a, 2007b). When making dolphin-associated sets, participating vessels allocated individual dolphin mortality limits are also required to have an onboard observer (for vessels with a carrying capacity exceeding 363 metric tons), use a Medina dolphin safety panel, conduct backdown after dolphins are captured, deploy at least one rescuer during backdown (see figure 11.9), carry specified dolphin safety/rescue equipment, and other measures (IATTC 2007b). As previously discussed, IATTC's measures have successfully reduced direct dolphin mortality, but dolphin-associated sets may cause miscarriages or separation and loss of calves, and hinder dolphin population recovery (Archer et al. 2004; Edwards 2006).

Many pelagic longline fisheries targeting species other than sharks, when not prevented by regulation, will retain the fins of captured sharks, which fetch a high value in the Asian dried seafood trade, and occasionally will retain meat and other parts (cartilage, liver oil, skin) from marketable species of sharks (Gilman et al. 2008). To address the social concern that shark finning is wasteful when a large portion of the shark is discarded, and ecological concerns over the sustainability of shark exploitation in fisheries, legally binding measures have been adopted by some RFMOs (e.g., International Commission for the Conservation of Atlantic Tunas, and IATTC) and nations to restrict shark finning practices so that carcasses must be landed if fins are retained (Gilman et al. 2008). In the few fisheries with adequate enforcement, these measures have resulted in large reductions in shark fishing mortality through increased discards of live sharks, but the majority of fisheries lack adequate enforcement, and shark finning practices have not been affected by these measures in these fisheries (Gilman et al. 2008).

Despite progress in identifying effective turtle avoidance methods for longlines, which in some fisheries has been shown to be economically viable (table 11.3), there are no legally binding measures in place by an intergovernmental organization, including RFMOs, to address sea turtle–fishery interactions (Gilman et al. 2007b).

IUU vessels are unlikely to employ bycatch reduction measures. IUU fishing also causes damage to fish stocks and economic losses to society. Several regional fishery bodies have taken steps to reduce IUU fishing, including instituting requirements for vessel monitoring systems (electronic transmitters, placed on fishing vessels, which transmit information about the vessel's position to enforcement agencies via satellite), managing lists of authorized and illegal vessels, port and at-sea inspection programs, and trade documentation programs (Lack 2007). The RFMO's catch and trade documentation programs are believed to have failed in preventing IUU fishing. This is due to inadequate laws and weak enforcement, as well as corruption, including laundering and mislabeling seafood, illegal at-sea transshipment, and noncompliance by some RFMO members. Recommended solutions involve technological changes (e.g., instituting mandatory electronic catch documentation, to reduce forgery and manipulation) and supply chain practices (e.g., prohibiting transshipment at sea) (Lack 2007).

Input and output controls contribute to managing overall bycatch levels. The five tuna RFMOs have taken steps to attempt to address tuna-fishing overcapacity, including through limited entry (through registers and licensing), catch quotas for member nations or individual participants in a fishery through individual quotas, and temporal closures. Overall, the tuna RFMOs have not been successful in preventing continued growth of tuna fleets (Bayliff et al. 2005).

Observer coverage is generally insufficient in commercial tuna fisheries. For example, worldwide, 40 nations are engaged in longline fishing, of which only 15 have observer programs (Beverly and Chapman 2007). WCPFC has adopted a target of 5 percent observer coverage. CCSBT adopted a target of 10 percent observer coverage of members' longline fisheries, and data standards have been established. However, the collection of seabird bycatch data is voluntary, and members are not required to share observer data with CCSBT. IOTC lacks observer coverage requirements. Observer programs are needed that include a goal of monitoring bycatch, and sufficient observer coverage rates are needed to allow for relevant statistical analyses and data recording protocols, in part, to understand bycatch interactions, including documenting interaction rates to provide a basis for fleetwide extrapolations and identifying when and where interactions occur. The objective determines the appropriate onboard observer coverage rate. For instance, an observer program designed to ensure that sea turtle annual interaction caps are not exceeded, or to institute a compensatory mitigation program, would require 100 percent coverage, while determining fleetwide annual bycatch interaction levels and rates might require 20 percent coverage (FAO in press).

The RFMO process has largely failed in addressing bycatch problems and preventing overexploitation of tuna stocks, in part because consensus-based decision making has often prevented RFMOs from adopting appropriate measures, and because of low compliance by member states with effective RFMO measures (Rosenberg 2003; Safina and Klinger 2008). There is no indication that the wholesale changes needed to correct these problems of political will and compliance will occur in the near future.

The mandate of regional fishery bodies, including RFMOs, is usually to cooperate in maintaining populations of exploited species at sustainable levels. As ecosystem considerations are a relatively new focus, there are few instances where regional fishery bodies' mandates explicitly reference the conservation of nontarget species (FAO in press). The mandate of these bodies should be broadened to cover issues relating to the sustainability of vulnerable bycatch species. However, ultimately, RFMO conservation and management measures will be effective only if member state compliance substantially improves and political will to allow RFMOs to adopt effective measures develops.

11.4.2. Fishing Industry

Voluntary initiatives by the fishing industry related to reducing unwanted bycatch have been limited and generally not proactive. Voluntary industry initiatives have primarily resulted from incentives to comply with government measures, as well as market-based and social factors. In longline fisheries, voluntary industry fleet communication programs (Gilman et al. 2006b) and industry self-policing (Fitzgerald et al. 2004), instituted in response to incentives created by regulatory measures, have successfully reduced bycatch. An effective voluntary industry initiative to address bycatch has been identified in only one commercial tuna fishery (U.S. North Atlantic longline swordfish fishery), which ceased to be formally active in 2003 (Gilman et al. 2006b). Recently, several voluntary initiatives have involved the exchange of traditional J-shaped hooks for circle hooks in order to assess pelagic longline fishery-specific efficacy at reducing sea turtle interactions and economic viability (e.g., Largacha et al. 2005). Hooks are largely a disposable, high-turnover item, and many vessels select cheap, short-life hooks (Gilman et al. 2006c). It is unclear at this incipient stage whether, once the free circle hooks require replacement, vessel operators will replace them with circle or traditional hooks, because circle hooks are currently more expensive and less robust. While unrelated to bycatch, in response to an excess supply of fish to tuna canneries and concomitant reductions in prices for skipjack from canneries, some owners of tuna purse seiners formed the World Tuna Purse-Seine Organization, which temporarily limited fishing effort by their vessels.

11.4.3. Retailer and Buyer Tuna Sourcing

Environmental nongovernmental organizations and, to a degree, consumers are increasingly demanding that seafood sold by retailers and restaurants be sustainably produced. Approaches by major grocery retailers to demonstrate that their seafood comes from sustainable fisheries have been diverse. There has been a recent proliferation of programs assessing the sustainability of individual fisheries or seafood species. These include in-house retailer programs, including the assessment of fisheries against retailer-established sustainability criteria; individual retailer partnerships with environmental nongovernmental organizations who conduct assessments and make recommendations for sustainable seafood sourcing; and use of a retailer ecolabel. There are also numerous third-party programs for marine capture fisheries, including ecolabeling programs and consumer guides, which assess the sustainability of individual fisheries, rank the relative sustainability of individual seafood species, or rank retailers based on the sustainability of their seafood sourcing practices. Sustainability assessment programs provide large market-based incentives for some fishing industries to meet sustainability criteria (e.g., Johnston et al. 2001). While relatively new and difficult to predict how it will develop, these market-driven incentives for sustainable seafood production may eventually become the strongest "voluntary" incentive for the tuna industry to improve practices.

Retailers, buyers, distributors, processors, and tuna fishing industries have identified the need for (1) improved scientific rigor of some assessment programs and (2) a single set of minimum sustainability standards to address confusion and diminished confidence created by the recent proliferation of competing certification and ecolabeling programs (FAO 2007; International Union for the Conservation of Nature and Western Pacific Regional Fishery Management Council 2008). Competing certification programs have produced conflicting determinations of the sustainability of individual fisheries, contributing to the confusion created by multiple assessment programs employing different standards and assessment methods.

As the sustainable seafood movement matures, retailers and restaurant chains may harmonize their methods for sustainable seafood sourcing, eliminating all but the most scientifically rigorous assessment programs. A welcome development would be the adoption of international guidelines for national competent authorities for fishery sustainability certification and labeling. These competent authorities would be responsible for establishing national standards for certification and labeling seafood products, which state that the product comes from a sustainable source, similar to standards for products certified as being organic or meeting safety and quality standards. These national sustainability standards would apply to assessment methods employed by government, retail and fishing industries, and environmental nongovernmental organizations.

11.5. CONCLUSIONS

There has been mixed progress in addressing unwanted bycatch in longline and purse seine tuna fisheries. It is likely that, given sufficient investment in research and development, economically viable changes in fishing gear and methods are possible to nearly eliminate bycatch in tuna fisheries. However, even in the gear types where substantial progress has been made, despite the availability of effective bycatch reduction methods that, in some cases, also increase fishing efficiency and provide operational benefits, the majority of fleets do not employ these methods (e.g., Brothers et al. 1999; Gilman et al. 2005). Furthermore, despite the fact that the tuna fishing industry recognizes that their long-term viability relies on the availability of tuna resources at sustainable and optimal levels (International Union for the Conservation of Nature and Western Pacific Regional Fishery Management Council 2008), voluntary industry action to reverse and prevent further overexploitation of tuna stocks and to address bycatch issues has been extremely limited. While RFMOs have made recent progress in addressing bycatch, through the adoption of legally binding conservation measures, for some fishing gear types and some bycatch species groups (Gilman et al. 2007b), compliance by many member states is likely low, where observer programs and national management frameworks are weak or nonexistent, preventing definitive assessments. Where intergovernmental organization and fishing industry initiatives have generally been ineffective, we can be cautiously optimistic that ecolabeling and other certification programs for marine capture fisheries, and adoption of suitable sustainable seafood sourcing policies by retailers and seafood buyers, are becoming an effective "voluntary" incentive for the fishing industry to improve practices and national and international authorities to improve management.

Recognizing this context, combined, several approaches may improve the sustainability of commercial tuna fisheries:

- Increase investment to augment progress in addressing bycatch problems involving sea turtles in purse seines, sharks in both longlines and purse seines, cetaceans in both longlines and purse seines, and juvenile and undersized tunas in purse seines.
- Increase investment to better understand indirect adverse effects from purse seine sets on dolphin schools.
- To maximize industry use of effective bycatch reduction methods, where possible, identify

measures that are practical and convenient for use by crew and are economically viable—or, better yet, provide operational and economic advantages.

- Where needed, revise the mandate of regional fishery bodies to include consideration of ecosystem effects of tuna fisheries, with explicit reference to the conservation of nontarget species occurring in the same ecosystem.
- Require adequate onboard coverage by international observers for the purpose of monitoring bycatch trends and levels, which would improve compliance with RFMO measures.
- Modify RFMO legal frameworks so that RFMOs must adopt the scientific committees' recommendations. This could eliminate the current tendency for scientific advice to be ignored by RFMOs, which results from industry lobbying, interference by politicians, and the inability of member states to reach consensus on specific approaches for the sustainable use of shared fisheries resources.
- Establish and manage a representative system of protected area networks on the high seas to contribute to the management of interactions between marine capture fisheries and highly migratory sensitive species groups, and to contribute to reversing and preventing overexploitation of target stocks.
- Improve measures to eliminate IUU tuna fishing.
- Involve the fishing industry more in its own governance. This could instill a sense of industry responsibility for their long-term viability, and improve tuna fishery sustainability.
- Assess the sustainability of individual tuna fisheries under scientifically rigorous certification and ecolabeling programs, and have retailers and buyers adopt sustainable tuna sourcing policies. Market-driven incentives from certification programs and retailer and buyer sourcing policies may become the strongest "voluntary" incentive for the tuna fishing industry to improve sustainability and management effectiveness.

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Note

1. "Target" catch is the catch of a species or species assemblage primarily sought in a fishery, while "nontarget" catch is the catch of a species or species assemblage not primarily sought. "Incidental" catch is the portion of nontarget catch that is retained, while "discards" is the portion of nontarget catch that is not retained.

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