Research and Management Techniques for the Conservation of Sea Turtles
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Reducing Incidental Catch in Fisheries

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Incidental catch in fisheries is widely recognized as a major mortality factor for sea turtles. Several gear types, including shrimp trawl nets and fish seines, are known sources of injury and mortality. Pritchard *et al.* (1983) offered three solutions for reducing mortality: restricting fishing activity in areas and during seasons when sea turtles concentrate, pulling trawls and other fishing gear to the surface more frequently, and using excluder devices to release sea turtles from trawls. The description and analysis of the incidental catch problem offered by Pritchard *et al.* (1983) more than a decade and a half ago constituted the best available information at that time. While there is still much to learn about the extent of and solutions to the incidental capture of sea turtles in fishing gear, new information is now available.

In an extensive national review of the threats to sea turtles, shrimp trawling was singled out as the most important human-associated source of sea turtle mortality to "juveniles, subadults, and breeders in U.S. coastal waters" by the National Research Council (1990). The report estimated the annual mortality of loggerhead *(Caretta caretta)* and Kemp's ridley *(Lepidochelys kempii)* turtles associated with shrimping at between 5,500-55,000. Other trawling, traps, gill nets, longlines and entanglement in discarded fishing gear were also cited as major sources of mortality. Mortality from discarded fishing line was mentioned under the general area of entanglement, but there was little discussion of the capture of sea turtles by hook and line recreational fishing.

Current information indicates that the major sources of sea turtle mortality by fishing gear worldwide are: (1) trawling; (2) pelagic and bottom longlines; (3) gill/entanglement nets or entrapment gear *(e.g.,* seines, pound nets); (4) entanglements in buoy or trap lines; and (5) hooks and lines from recreational and commercial fishing. The purpose of this chapter is to summarize information available on gear that impacts sea turtles, the known or possible magnitude of takes by gear type, and potential solutions to reduce the take. Whenever practicable, comatose sea turtles recovered from fishing gear should be resuscitated (described below).

Trawling

Trawls are highly efficient gear for catching a variety of marine crustaceans and fish around the world. A variety of types are in use, with sizes ranging from 10 ft (3 m) head rope length (used by artisinal and recreational fisherman) to massive commercial trawls up to 200 ft (61.5 m) head rope length. Fortunately for sea turtles, massive trawls typically target cold water fish species where sea turtles are unlikely to occur. However, in the U.S. Gulf of Mexico shrimp fishery, the simultaneous use of four 100 ft (30.75 m) trawls by large shrimp vessels is not uncommon.

Problem Quantification

There are no reliable estimates of the global extent of trawl fishing in areas where sea turtles occur, but the incidental take of sea turtles in shrimp trawls is widely cited as very significant. Based on worldwide shrimp trawling effort, and making assumptions about the rate of capture (based on documented U.S. takes), a reasonable estimate of annual mortality of sea turtles in shrimp trawls worldwide is 150,000.

Worldwide, the principal marine species targeted in warm waters by trawling is shrimp. Fish are also harvested extensively, not always as a directed fishery with species specific trawls, but incidentally in shrimp trawls. Regardless of the target species, if bot-

tom trawls occur in habitats frequented by sea turtles, turtles will be taken as bycatch. Unable to surface to breathe, many of those taken will drown.

Mitigation

The use of excluder devices, reduced tow times, and/or time and area closures are among the options touted to prevent or reduce turtle mortality. The Turtle Excluder Device (TED) has become the standard for reduction of sea turtle mortality from shrimping and, to a lesser extent, from fish trawling. The principle of the TED is simple: a barrier with an opening through which sea turtles voluntarily or involuntarily escape is installed into the trawl. Small openings in the TED, either spacing between the metal bars of a grid or large mesh size (8 in / 20 cm) webbing panels, allow most of the target species to pass through the openings into the rear or cod end of the net.

Research by the U.S. National Marine Fisheries Service (NMFS), fishermen and universities, has demonstrated that some types of TEDs work more efficiently at both target species retention and sea turtle release. All TEDs likely lose some target species, either because shrimp, which are weak swimmers, escape out the turtle release opening, or large fish do not pass through the openings in the TED and also escape out the turtle release opening. Despite some shortcomings, to date the TED is the best technical solution to allow turtles to escape from trawls with minimal effect on the target catch. Research and experience confirm that grid-type ("hard") TEDs seem to be the best for both purposes. Mesh webbing ("soft") TEDs divert a greater proportion of shrimp through the exit openings and, due to net stretching, create pockets in which turtles can become entrapped.

An oft overlooked part of the shrimp trawl fishery is the use of try nets or sample trawls. Because these trawls are pulled frequently to provide fishermen with an indication of what the large nets are catching, it was believed that they had little impact on sea turtle mortality. However, in almost 20,000 hr of tows conducted between 1992-1995 in U.S. waters, 41 turtles captured in try nets were recorded by NMFS observers for a calculated catch rate of about 0.002 turtles/net hr/try net (average try net size is 15 ft, or 4.6 m). By comparison, Henwood and Stuntz (1987) reported a catch rate of 0.0031 turtles/net hr/100 ft (30.75 m) net, for observer data collected from commercial trawls between 1973-1984. While most of these turtles observed captured in try nets were alive when brought aboard, their ultimate fate is unknown.

Reducing tow times can improve sea turtle survival under certain conditions. However, recent research and review of physiological data suggest that forced submergence of turtles for even a few minutes causes changes in their blood chemistry. Recovery to normal levels is dependent on the length of time submergence is forced, as well as turtle size. For small turtles, recovery from even a few minutes of forced submergence can require as long as 24 hr. Thus, reduced tow times may not be a viable alternative to TEDs where the conservation of sea turtles is the goal.

Pelagic Longlines

Longlines, used for the capture of pelagic species such as swordfish and other billfish, tunas, and sharks, consist of a surface line buoyed at each end, with lines of smaller diameter (sometimes called gangions) spaced uniformly from the main line. Baited hooks are attached to the smaller lines which hang vertically in the water column. Longlines can be several miles long, and are deployed from vessels and allowed to soak, usually overnight. The lines are retrieved after the specified soak time, and the catch brought aboard. There is increasing evidence that sea turtles both bite the baited hooks and become entangled in the lines. Most of the animals caught on longlines are released alive, but they are released with hooks lodged in their gastrointestinal tracts. There is a growing body of evidence that many of these injuries are fatal and a large number of hooked turtles subsequently die. Swordfish, a major target species, tend to concentrate along frontal zones with high topographic relief and high biological productivity. These are often the same areas where sea turtles concentrate, creating a scenario for incidental take.

Problem Quantification

There are no worldwide estimates of sea turtle bycatch in pelagic longline gear, but billions of hooks are set each year. It is estimated by the NMFS Northeast Fisheries Science Center that in the U.S. Atlantic Ocean swordfish fishery, 1218 sea turtles were taken in 1992. More than 20,000 subadult loggerhead turtles are hooked annually by the Spanish longline fleet (in the eastern Atlantic and in the Mediterranean Sea) (Aguilar *et al.*, 1995). Additional longline fleets operate in the Mediterranean Sea and eastern Atlantic waters, so this number represents only part of the total take by longlines in the region.

Few data are available for the Pacific and Indian Oceans. In 1990 Japanese researchers estimated the

Japanese tuna longline fleet in the Western Pacific and South China Sea captured 21,200 turtles annually, with 12,296 mortalities (Nishemura and Nakahigashi, 1990); in 1991 NMFS estimated the longline fleet based in Hawaii takes an additional 1,232 turtles, of which 517 die. On a worldwide basis, turtle mortality in the Japanese tuna longline fleet is estimated to be 42% (Nishemura and Nakahigashi, 1990).

Mitigation

Mitigating measures to reduce sea turtle take should include additional research on the distribution and abundance of sea turtles, as well as a reduction of fishing effort when sea turtles occur in concentrations. Alternatives include limiting entrants to these fisheries, modifying fishing quotas, setting seasonal limits based on sea turtle distribution and abundance, and pulling lines more frequently.

Research on gear types can also be undertaken to reduce potential interactions with sea turtles. Alternative gear placement, bait, and hook types and materials can be developed to reduce interaction with turtles. The Japanese are reportedly conducting research on a rubber or plastic iridescent material that turtles supposedly bite in preference to the baited hooks; however, such a solution would not address the twin threat of line entanglement.

Research on reducing sea turtle take by longlines is in its infancy compared to technical solutions in the shrimp trawl fishery because the incidental take of sea turtles by longline gear is a problem documented only fairly recently. However, longline fisheries are expanding rapidly throughout the world, and this problem needs to be addressed.

Bottom Longlines

Bottom longlines differ from pelagic longlines in that they are set on the sea bottom, usually over a reef or other hard bottom. Bottom longlines use the principle of a main or mother line from which smaller diameter lines with baited hooks are evenly spaced. Principal species targeted are reef fish *(e.g.,* snappers, groupers). Evidence on the incidental take of sea turtles on bottom longlines is sparse, but they have the potential to take reef dwelling turtles such as loggerheads and hawksbills *(Eretmochelys imbricata).*

Problem Quantification

There are no national or regional data from which to estimate the global extent of sea turtle mortality due to bottom longline fishing effort.

Mitigation

Possible measures to reduce sea turtle takes include pulling lines more frequently, setting gear in areas where turtles are not in abundance, and using degradable hooks that would not cause long-term problems for turtles. More research is needed to define the extent of the problem, and to devise potential solutions.

Gill/Entanglement Nets

There are generally two types of gill nets used in fisheries around the world. Pelagic (deep ocean) drift nets target species such as swordfish and other billfish, sharks, mackerels, and dolphinfish. These large drift nets are an indiscriminate fishing technique that, in addition to the target catch, take various non-target species of sea turtles, marine mammals, seabirds, and other marine life. On the other hand, coastal gill nets are used around the world to capture coastal fishes. Mesh sizes vary depending on the target species, mainly between 2-3 in (5-7.6 cm) stretch mesh up to the 12-16 in (30.5-40.6 cm) mesh used in shark gill nets.

Problem Quantification

Because of the indiscriminate nature of gill nets, sea turtles are likely to be captured in both the pelagic and coastal habitats where they occur. As an example, incidental capture of leatherback turtles *(Dermochelys coriacea)* in the swordfish gillnet fisheries of Chile and Peru has been implicated in the recent collapse of the breeding colony on the Pacific coast of Mexico (Eckert and Sarti, 1997). Until recently, Mexico supported the largest nesting assemblage of leatherback sea turtles in the world (Sarti *et al.,* 1996). Mortality of sea turtles entangled in Chilean gillnets is estimated to be 80% (Frazier and Montero, 1990).

In some parts of the world, such as in Brazil, coastal gill nets represent a larger mortality problem for turtles than trawling (Maria Marcovaldi, Projeto TAMAR, pers. comm.). Projeto TAMAR (the national sea turtle research and conservation program in Brazil) is working with fishermen to tag and release turtles caught in nets, but this project needs to be expanded.

Mitigation

Measures to reduce the incidental take of sea turtles in gill nets include setting nets in areas where turtles are unlikely to be present, limiting the length or depth of the nets, reducing the soak time of nets and requiring nets to be attended, establishing quotas

or restrictions for target species, and using mesh sizes that are less likely to take turtles.

To reduce the incidental catch problem on Florida's east coast (USA), the State of Florida has limited the size of gill nets to no more than 600 yd (554 m), established a green turtle conservation zone in the area of greatest take, limited the number of gill nets allowed to one per fisher, prohibited use of trammel nets (which are actually a double gill net of varying mesh sizes), and established a zero soak time (that is, fishermen were required to begin retrieving their nets as soon as the set was complete). Shortly before these measures were instituted, the citizens of Florida, through constitutional amendment, banned the use of all gill nets in state waters in November 1996. Fishery managers around the world may take note of the Florida situation, which illustrates that a public outcry can force stringent management measures when less stringent measures are too little or too late.

Seines, Purse Seines, and Pound Nets

Seine nets are gear types that can be considered small mesh gill nets that are pulled through the water to capture a target species of fish both for food and bait. Usually one end of the net is anchored in shallow water or on shore and the other end carried by boat or wade fishermen out to sea; then brought back to shallow water or shore, entrapping the target species. Purse seines are deployed from vessels or boats. The target species is encircled by the net and the bottom of the net pursed or closed to entrap the target species. Pound nets employ the entrapment principle, and are generally anchored with stakes forming a pound or net corral. A single length of netting called a lead line stretches perpendicular from the middle of the pound and is used to guide the target species into the pocket of the net. Pound nets are used in coastal bays and sounds where the water is generally calm.

Problem Quantification

All three gear types (haul seines, purse seines, pound nets) have been implicated in the capture and mortality of sea turtles (NRC, 1990). However, mortality of sea turtles in these gears is probably not significant because turtles are usually not forced to be submerged and the mesh sizes used are usually small enough that turtles are not entangled. However, pound nets with more slack have more potential for accumulation of debris and marine organisms.

Significant mortality of sea turtles captured in seines is likely to be the direct result of fishermen who kill them for meat.

Mitigation

Measures to reduce the incidental take of sea turtles in pound nets would include setting the nets in areas where sea turtles are unlikely to occur. However, based on available evidence, few sea turtles are likely killed in pound nets, as long as due care is employed in releasing the animal. The type of lead lines used in some pound net fisheries can be modified, sometimes simply by stretching it tighter to avoid the potential for capture. In the case of haul seines and purse seines, since this gear is continuously tended by fishermen any turtles incidentally captured can be released from the net in a timely fashion.

Buoy and Trap Lines

Entanglement of sea turtles in buoy lines from anchor markers, crab pots, lobster pots, and fish traps has been documented in the U. S. and elsewhere. Loggerhead turtles feed on spiny lobsters and crabs and have been known to break into traps to reach the crustaceans. Kemp's ridleys also feed on crabs and have been known to destroy traps in search of prey. In addition to the possible entanglement in buoy lines, some turtles are likely killed by fisherman because of gear damage.

Problem Quantification

There are no national or regional data from which to estimate the global extent of sea turtle mortality due to accidental entanglement in buoy and trap lines.

Mitigation

Obvious alternatives to mitigate the potential for sea turtle entanglement in buoy/trap lines are reduction of fishing effort, establishment of restricted fishing zones, and requirements to tend fishing gear more frequently. Management actions to conserve spiny lobster and stone crab stocks, instituted at the state and federal levels in the U.S., have included seasonal fishing restrictions, limits on the number and sizes of traps, and the installation of biodegradable panels in traps to limit their fishing life. Some of these measures will reduce the chances of entanglement of sea turtles.

Hook and Line Gear

The abundance of fishing gear using hooks and line around the world is unquantifiable. Hooks, and

especially discarded fishing line, have the potential to adversely impact all species of sea turtles. Foul hooking and ingestion of hooks are additional problems.

Problem Quantification

There are no national or regional data from which to estimate the global extent of sea turtle mortality due to accidental catch by hook and line gear.

Mitigation

There are no obvious or reasonable mitigation measures to reduce this take, other than a general educational effort. Fishermen should be continually reminded not to discard their fishing gear in the marine environment, and should be encouraged to use hooks of degradable material. Educational efforts should include information on the proper release of turtles. Where feasible, programs should be established to notify marine resource or protection agencies of turtle takes by hook and line gear. This would at least help ensure proper release of turtles, recording of the incidents, and provide opportunities for tagging and other research.

Resuscitation and Release

Sea turtles that are dead or actively moving should be released over the stern of the boat. In addition, they should be released only when trawls (or other offending gear) are not in use, when the engine gears are in neutral position, and in areas where they are unlikely to be recaptured or injured by vessels. Resuscitation should be attempted on sea turtles that are comatose or inactive but not dead by: (1) placing the turtle on its carapace (back) and pumping its plastron (breastplate) with hand or foot, or (2) placing the turtle on its plastron and elevating its hindquarter several inches for a period of 1-24 hr. The amount of elevation depends on the size of the turtle; greater elevations are required for larger turtles. Sea turtles being resuscitated must be shaded and kept wet or moist.

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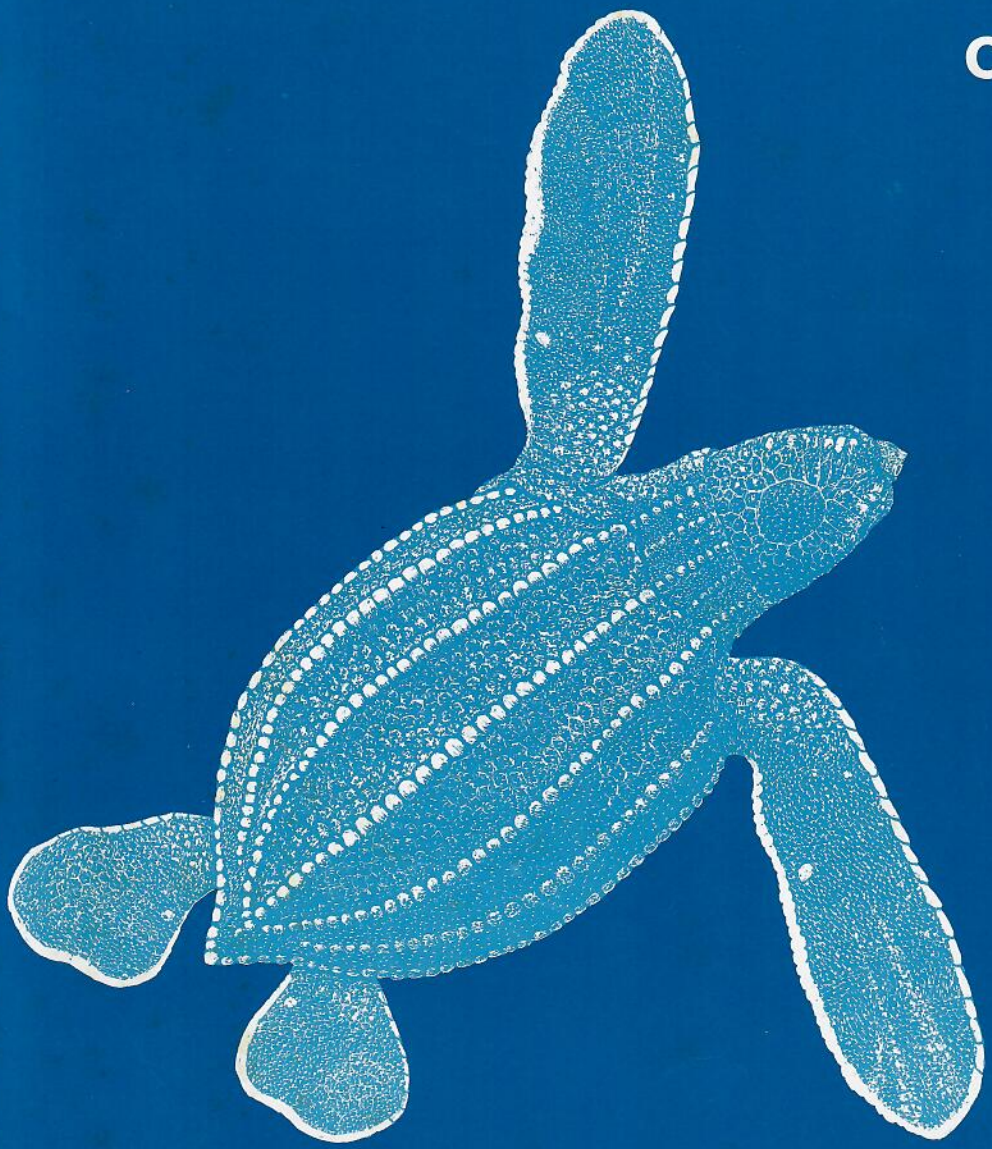

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