Introduction

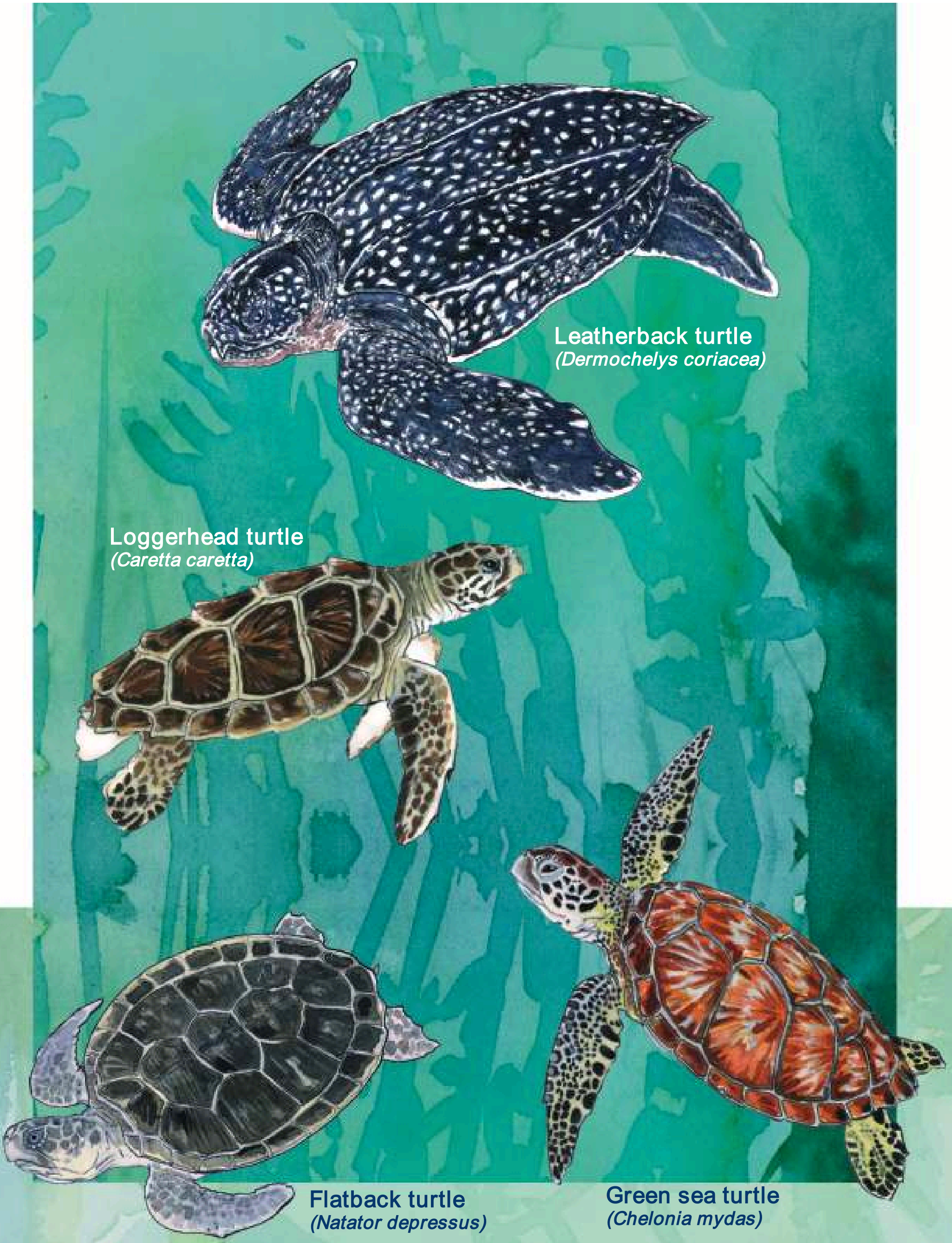
Background

The FAO Code of Conduct for Responsible Fisheries (CCRF) calls for the sustainable use of aquatic ecosystems and requires that fishing be conducted with due regard for the environment. Article 7.2.2d of the CCRF specifically addresses biodiversity issues and conservation of endangered species and, in so doing, calls for the catch of non-target species, both fish and non-fish species, to be minimized. The CCRF also promotes the maintenance, safeguarding and conservation of biodiversity by minimizing fisheries impacts on non-target species and the ecosystem in general.

These guidelines were developed to support the implementation of the CCRF. They are addressed primarily to decision-makers within fisheries management authorities and to interest groups such as fishers, fishing companies, fishers' organizations, relevant non-governmental organizations (NGOs) and others. They aim to help these interest groups to identify and implement appropriate measures to reduce interactions with sea turtles and thereby help to address the issue of sea turtle mortality in fishing operations.

Figure 1. The seven species of sea turtles

Figure 1. Continued.



These guidelines were drafted at the request of the FAO Committee on Fisheries (COFI), which raised the question of sea turtle conservation at its 25th session. They are the product of two international meetings: an Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context (March 2004) and a Technical Consultation on Sea Turtle Conservation and Fisheries (November/December 2004). "Guidelines to Reduce Sea Turtle Mortality in Fishing Operations" were developed at the latter meeting.
These guidelines were endorsed at the 26th session of the COFI, which called for their immediate implementation by members and regional fishery bodies (RFBs). They also provided the key inputs for the preparation of these guidelines.

The key objectives of these guidelines are to: (i) present measures for avoiding or minimizing sea turtle interactions in marine capture fisheries; and (ii) consolidate existing handling and release guidelines.

Identification, distribution and biology of sea turtles

There are seven species of sea turtles, i.e. the loggerhead (*Caretta caretta*), the green turtle (*Chelonia mydas*), the hawksbill (*Eretmochelys imbricata*), the Kemp's ridley (*Lepdochelys kempi*), the olive ridley (*L. olivacea*), the flatback (*Natator depressus*) and the leatherback turtle (*Dermochelys coriacea*) (Figure 1).

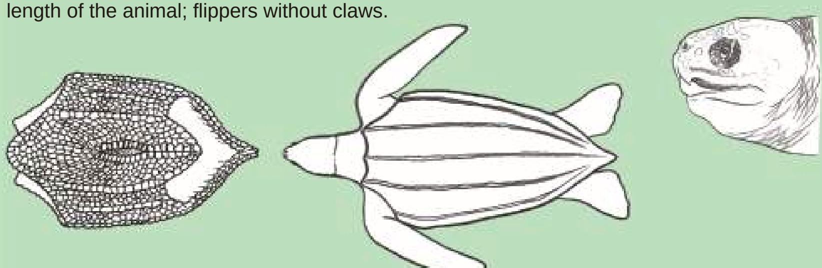
In the areas where they co-occur, they can easily be distinguished (see identification key below).

Sea turtle identification key

1a. **FAMILY DERMOCHELYIDAE**

Dermochelys coriacea
Leatherback turtle

Carapace (dorsal part of shell) with 5 distinct ridges running the length of the animal; flippers without claws.



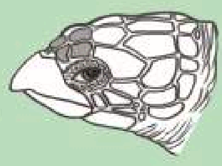
1b. FAMILY CHELONIDAE

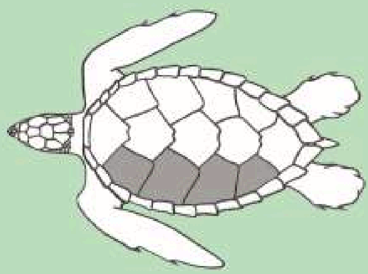
Carapace with no ridges, consisting of large hard scutes; flippers with one or more claws.

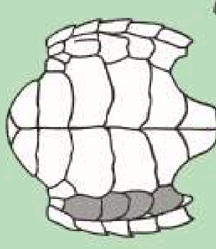
2a. Carapace with 4 lateral scutes

Eretmochelys imbricata
Hawksbill sea turtle

3a. Beak smooth, hawklike; 2 pairs of scales between eyes; flippers with 2 claws; carapace elliptical; underside with 4 lateral scutes, without pores

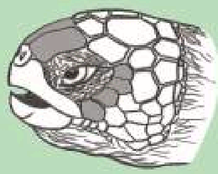


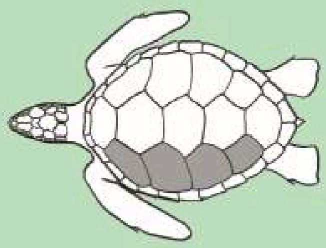


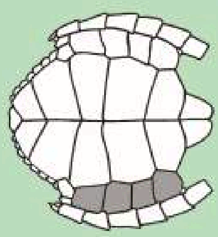


Chelonia mydas
Green sea turtle

3b. Beak serrated; 1 pair of scales between eyes; 4 scales posterior to eyes; flippers with 1 evident claw; carapace oval; underside with 4 lateral scutes

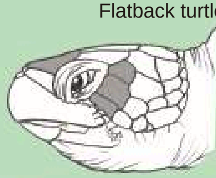


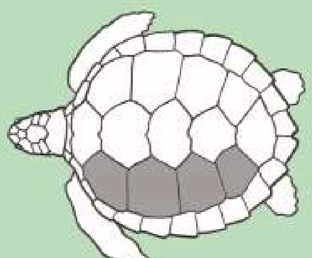


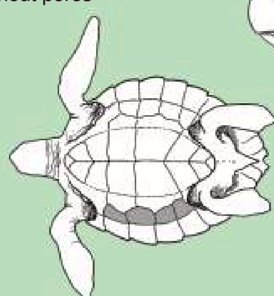


Natator depressus
Flatback turtle

3c. Beak smooth; 1 pair of scales between eyes; 3 scales posterior to eyes; flippers with one evident claw; carapace round and flattened, with slightly upward-folded margins; underside with 4 lateral scutes without pores



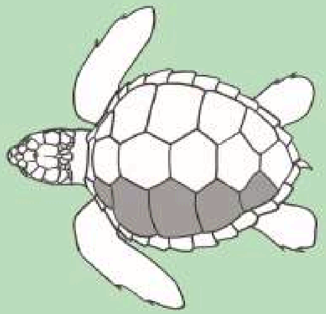
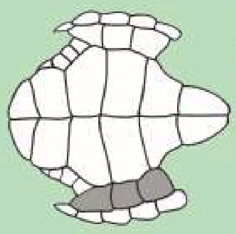
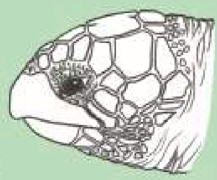




2b. Carapace with 5 lateral scutes

Caretta caretta
Loggerhead turtle

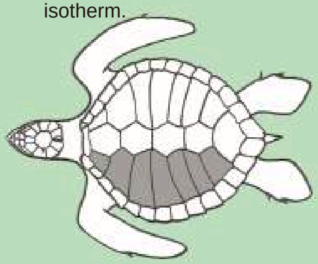
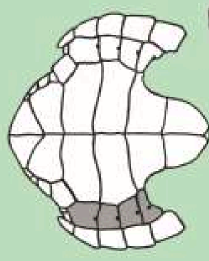
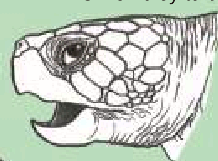
4a. Carapace elongated, its length always greater than its width; underside with 3 lateral scutes without pores.

4b. Carapace nearly round, its length similar to its width; underside with 4 lateral scutes.

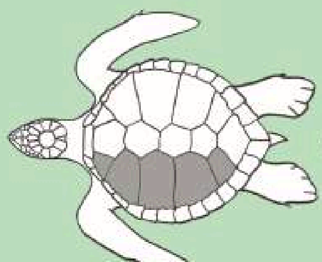
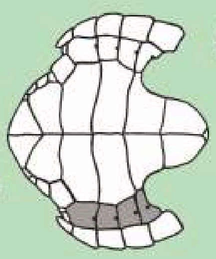
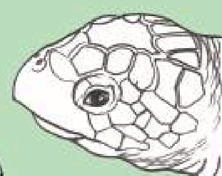
Lepidochelys olivacea
Olive ridley turtle

5a. Carapace with usually 6 or more lateral scutes; pantropical, usually between 20° C surface isotherm.

Lepidochelys kempii
Kemp's ridley turtle

5b. Carapace with 5 lateral scutes; restricted distribution, adults mainly in the Gulf of Mexico and off the east coast of the United States of America, to about 16º N.

Most sea turtles are widely distributed in tropical and subtropical waters of all oceans. A few species have a more restricted distribution, such as the Kemp's ridley with adults occurring in the Gulf of Mexico and juveniles with a broader distribution reaching northern European waters, and the flatback, confined to northern Australian waters (Figure 2a–2g).

Areas of possible occurrence   Main distribution areas

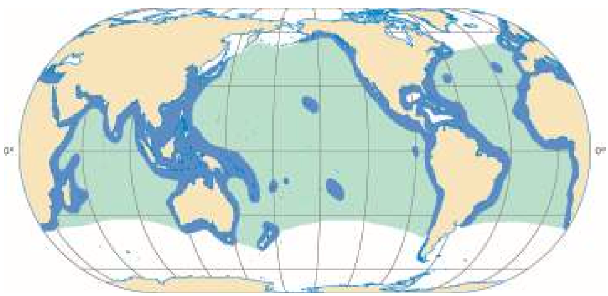


Figure 2a. Leatherback turtles (*Dermochelys coriacea*) are circumglobal, found from tropical to temperate regions.

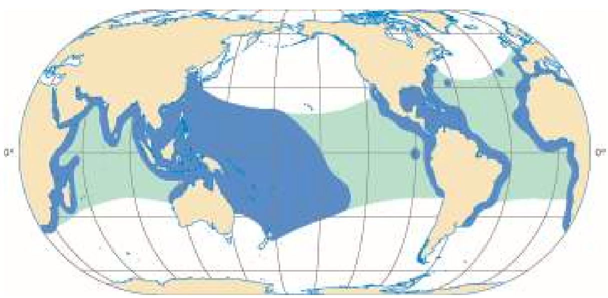


Figure 2b. Hawkbill sea turtles (*Eretmochelys imbricata*) are the most tropical of all sea turtles, found throughout central America and the Indo-Pacific Region.

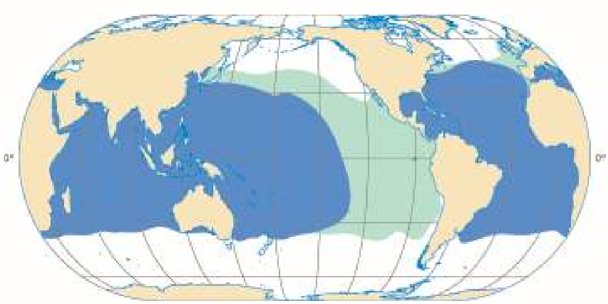


Figure 2c. Green sea turtles (*Chelonia mydas*) are widely distributed in tropical and subtropical waters, near continental coasts and around islands.

Figure 2d. Flatback sea turtles (*Natator depressus*) are indigenous to northwestern, northern, and northeastern regions of Australia and have the most restricted range of all sea turtle species.

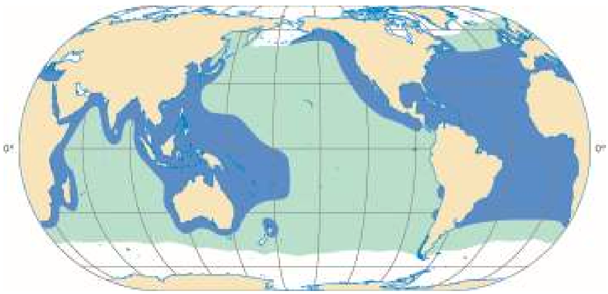


Figure 2e. Loggerhead sea turtles (*Caretta caretta*) are circumglobal, from tropical to temperate habitats.

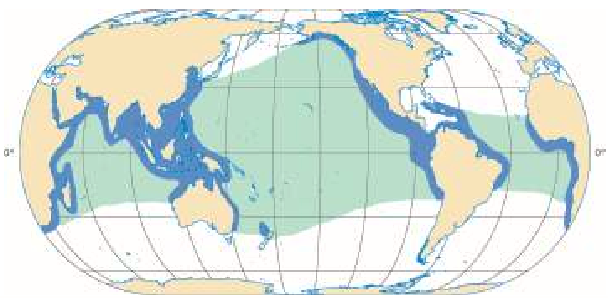


Figure 2f. Olive ridley sea turtles (*Lepidochelys olivacea*) are found in the tropical regions of the Atlantic, Indian and Pacific Oceans.

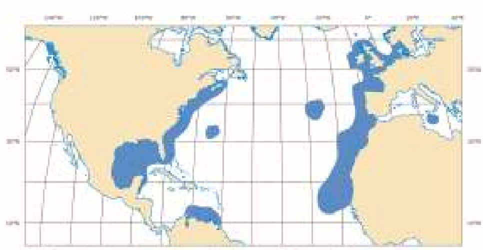
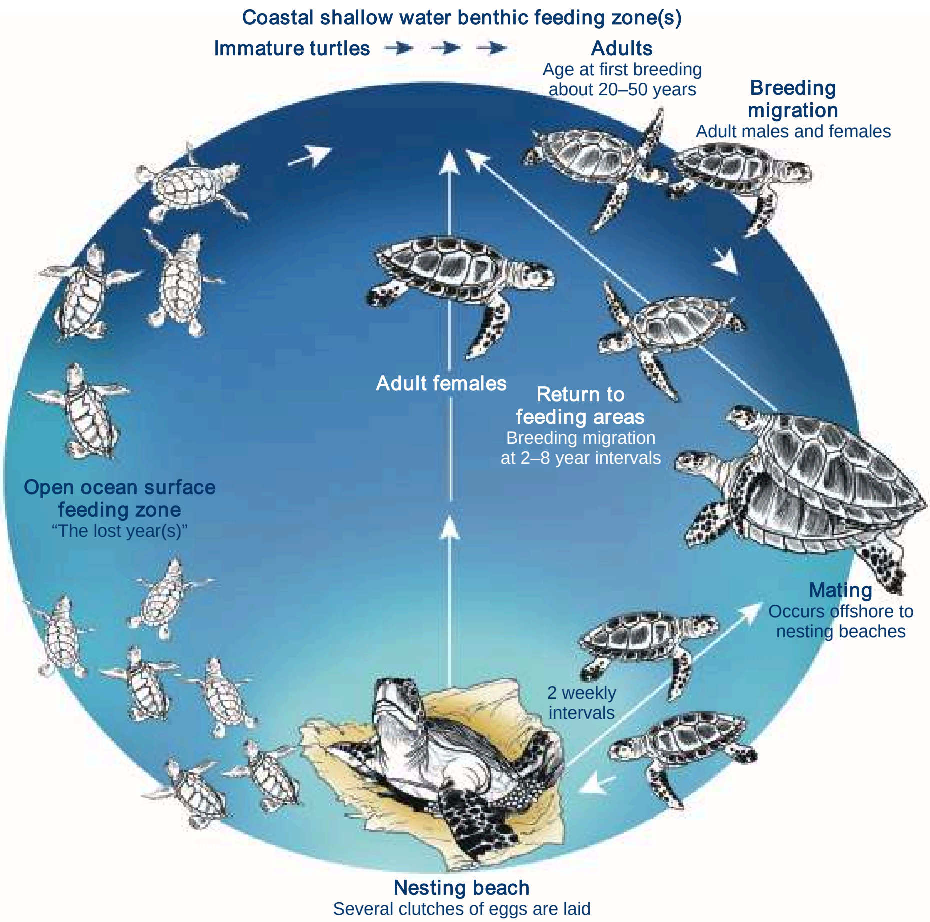


Figure 2g. Adult Kemp's ridley sea turtles (*Lepidochelys kempii*) usually occur in the Gulf of Mexico. Juveniles and immatures range between temperate and tropical coastal areas of the northwestern Atlantic Ocean. Occasionally, young turtles reach northern European waters and as far south as the Moroccan coast.

All species of sea turtles are long-lived, slow-growing species, characterized by a complex life cycle and utilizing a wide range of habitats (Figure 3). Sexual maturity is delayed in all species, with estimates varying in different species and populations, but usually exceeding 20, even 50, years. After mating, females dig nests in sandy beaches, and lay from 50 to 130 eggs per nest. Hatchlings crawl to seawater and swim towards the open ocean. After a period of time that varies according to species, juveniles return to coastal waters to feed on benthic organisms.

Figure 3. Life cycle and main habitats [1]



[1] After Lanyon, J.M., Limpus, C.J. & Marsh, H. 1989. Dugongs and turtles: grazers in the seagrass system. *In*: A.W.D. Larkum, A.J. McComb & S.A. Shepherd (eds), *Biology of Seagrasses: A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region*, pp. 610–634. Amsterdam, Elsevier.

Exceptions to this general pattern are the leatherback turtles, which remain pelagic throughout their life cycle, and the flatback turtles, which remain neritic throughout their lives. As the turtles grow and reach sexual maturity, both males and females leave their feeding grounds and migrate to the nesting beach. This periodic migration will continue throughout their lives. Females dig nests in dry sand, returning faithfully to the same beach each time they are ready to nest and returning to the sea either to rest before nesting again later that season or before beginning their migration back to their feeding ground.

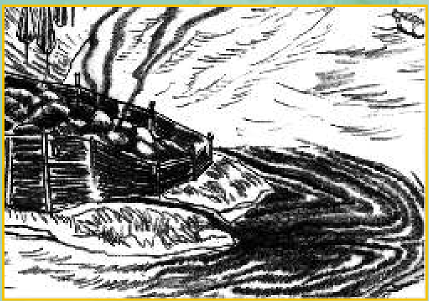
Threats to sea turtles

Because of their long life span, a life cycle that requires several habitat types, and their extensive distribution in terms of the distance they cover, sea turtles are affected by a range of different factors, some natural and others caused by human activities, at all stages of their life cycle (Figures 4a–d and 5).

These factors have an impact both in the terrestrial part of their habitat as well as in the marine environment. Impacts in the nesting environment (on sandy beaches) include: the direct take of adults for meat, oil, shells, etc.; the collection of eggs by humans; the predation of eggs by animals (e.g. dogs, pigs); climate change, which may affect embryo development; sea-level rise, a consequence of global warming that in some circumstances results in a reduction of nesting beach habitat; loss of nests due to hurricanes; and heavy utilization of nesting beaches by humans.

Figure 4. Examples of major threats to sea turtles

Figure 4a. Fibropapilloma tumours and pollution



In the marine environment, threats derive from climate change effects, including: changes in sea temperature, currents and oceanographic processes such as El Niño phases of the El Niño Southern Oscillation; fishery interactions; pollution (sea turtles eat a wide variety of marine debris such as plastic bags, plastic and tar balls, balloons); and boat collisions, particularly in coastal waters. In addition, a disease known as fibropapilloma, a tumorous growth that kills sea turtles, is now affecting large numbers of sea turtles around the world. It has been hypothesized that this epidemic, which is believed to be linked to toxic ocean pollution, is affecting sea turtles' immune system.

One of the greatest threats to sea turtle populations is capture in fishing gear. Longlines, trawls, gillnets and other types of gear catch sea turtles unintentionally, as bycatch.

Reliable data on sea turtle abundance and on the numerous causes of turtle deaths, which are necessary for accurate population assessments, are generally not available. In addition to a lack of data, it has proved difficult to identify all the factors that influence the abundance of sea turtles. As mentioned, because of the highly migratory nature of sea turtles and the large amount of hatchlings coupled with low survival rates, it is difficult to estimate overall populations.

Figure 4b. Tourism and coastal development

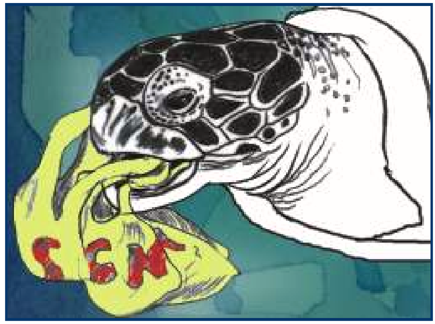


Figure 4c. Plastic bags/debris

There is, however, evidence that some sea turtle populations have declined dramatically in recent decades, and all sea turtle species whose conservation status has been assessed, are considered to be threatened or endangered. For example, it is estimated that the number of nesting leatherback turtles in the Pacific Ocean has declined by more than 95 percent in the past 20 years, and the number of nesting loggerheads has declined by about 80 percent over the same period. Unless action is taken soon, these sea turtles could disappear from the Pacific Ocean in the near future.

Actions that reduce interactions between fisheries and sea turtles, as well as initiatives that address other threats to sea turtles, may contribute to the recovery of turtle populations.

Figure 4d. Boat collisions

Sea turtle interactions in marine capture fisheries

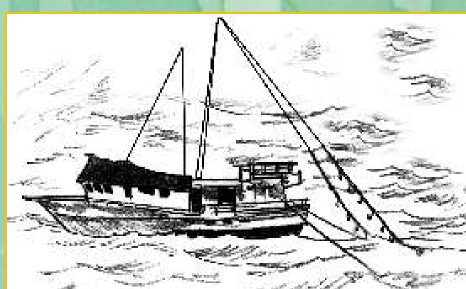
The expansion of fishing activities in coastal areas and on the high seas has contributed to the decline of several sea turtle populations.

As sea turtles cross the oceans from nesting beaches to foraging grounds and back again, they run the gauntlet of industrial and artisanal fisheries.

Turtles can become entangled in gillnets, pound nets, purse seines and the lines associated with longline and trap/pot fishing gear. Turtles entangled in these types of fishing gear may drown and often suffer serious injuries to their flippers from constriction by the lines or ropes. In addition to entangling turtles, longline gear can also hook turtles in the jaw, oesophagus or flippers. Trawls that are not fitted with turtle excluder devices (TEDs) do not allow turtles to escape, which may result in mortality through drowning. Fishing dredges, extremely heavy metal frames dragged along the ocean floor, can crush and entrap turtles, causing death and serious injury. In the Pacific, coastal gillnet and other fisheries conducted from a multitude of smaller vessels are of increasing concern. These artisanal fisheries can collectively have a very great impact on local turtle populations, especially leatherbacks and loggerheads, and this issue is only now gaining international attention.

Sea turtle interactions are known to be problematic in pelagic longline, gillnet, set net, pound net, trawl, purse seine and demersal longline fisheries that operate in the range of sea turtles, especially in the tropics and subtropics. For example, entanglement of leatherback turtles in surface set gillnets may be so frequent during the leatherback nesting season in some areas of the Caribbean that it causes expensive damage to gear, leading to time-consuming repairs. As a result,

Figure 5. Example of interactions between sea turtles and longline fishery



it is economically difficult for some gillnet fishers to operate when leatherbacks are most abundant, a period that accounts for a substantial part of the year.

Progress in reducing turtle interactions has more recently been achieved in shrimp trawl fisheries and pelagic longline fisheries, in both coastal and high seas fisheries for tunas, swordfish and other pelagic fish. Little progress has been made in reducing turtle interactions in purse seine fisheries, but assessments indicate turtle bycatch rates in purse seine fisheries, including entanglement in fish aggregating devices (FADs) deployed in these fisheries, is low relative to pelagic longline and gillnet fisheries. Turtle interactions in coastal artisanal fixed net fisheries, such as in gillnet, set-net, pound net and other fishing gear, is only now gaining international attention and mitigation measures are not yet well developed.

High risk areas, high risk fisheries and information gaps

The FAO Expert Consultation (FAO, 2004a) identified geographical areas where there is a high likelihood that interactions between sea turtles and fisheries could have a negative impact on sea turtle populations. For example, coastal fisheries may affect females migrating for nesting purposes, as well as juveniles and subadults. Trawls, gillnets, pelagic longlines and set-nets can potentially catch sea turtles when they are used in areas of sea turtle occurrence. Sea turtle populations that may be seriously affected by fishing operations and therefore require urgent attention include the:

- Pacific loggerhead;
- Pacific leatherback;
- Eastern Indian coast olive ridley.

To significantly reduce the impact of coastal fisheries on these most threatened sea turtle populations, it is recommended that attention be focused on fisheries management solutions in the following fisheries and regions:

- coastal trawl fisheries off southeast Asia;
- coastal gillnet fisheries off southeast Asia;
- coastal gillnet fisheries in south Asian waters;
- coastal trawl fisheries in south Asian waters;
- coastal gillnet fisheries in southeast Pacific waters;
- coastal gillnet fisheries in Baja California;
- coastal demersal longline fisheries in the southeast Pacific and Baja California waters; and
- pelagic longline fisheries in eastern Pacific waters.

Furthermore, there are regions and fisheries where information is largely unavailable and the FAO Expert Consultation (2004a) recommended that basic information be urgently collected for:

- coastal trawl and gillnet fisheries in the western Indian Ocean;
- coastal fisheries in the eastern Mediterranean; and
- coastal and offshore fisheries of the eastern central Atlantic.

Interactions between sea turtles and high seas pelagic longline fisheries targeting tunas and swordfish and operating primarily in the tropics and subtropics are a concern. The high seas pelagic longline fisheries that set baited hooks in the upper 100 m of the water column are believed to have an order of magnitude higher sea turtle interaction rate than deeper setting longline fisheries. Use of mitigation measures is therefore most urgent for those longline fisheries that operate in relatively shallow waters (less than 100 m), in areas where sea turtles occur and during times and seasons when they are particularly abundant.

According to the FAO Expert Consultation (2004a), longline fisheries are believed to pose a major threat to the following sea turtle populations:

- North and South Pacific loggerhead turtles;
- Eastern Pacific leatherback turtles; and
- Mediterranean Sea loggerhead and green turtles; mainly in the central and western parts of the Mediterranean Basin, loggerheads are also threatened by pelagic drifting gillnets (drift nets).

The report of the Expert Consultation also drew attention to the migration pattern of turtles:

- North Pacific loggerheads that originate in Japan migrate throughout the North Pacific, mainly between 28 and 40°N;
- leatherbacks originating in the Western Pacific migrate to the North Pacific to forage;
- leatherbacks originating in the Eastern Pacific move to the South Pacific to forage.

The role of IGOs, including RFMOs

In 2007, FAO conducted a review of initiatives by intergovernmental organizations (IGOs), including regional fisheries management organizations (RFMOs) and other RFBs, to address sea turtle interactions in marine capture fisheries. The FAO found that there are no IGOs that have put in place legally binding measures that require fishing vessels to implement sea turtle avoidance methods.

There are five RFMOs with responsibility for fisheries that interact with sea turtles. Some of these organizations have begun examining sea turtle bycatch, or have adopted voluntary measures to address bycatch as part of their overall fisheries management schemes. In addition, there are three multilateral agreements with the primary responsibility of regional sea turtle conservation. These instruments address a range of sea turtle conservation and protection issues and incorporate provisions to address interactions with fisheries. Although these agreements do not have fisheries management authority, they do carry obligations for signatory states to take bycatch-related actions for areas under their jurisdiction.

The chapter “Legal and Policy Frameworks” (p. 91) describes the global instruments that provide a legal framework for governments to advance the sustainable management of marine living resources, and it also describes the RFMOs with management responsibilities for fisheries that interact with sea turtles. Furthermore, Annex II lists: (i) RFMOs that directly establish measures to manage sea turtle interactions in marine capture fisheries; (ii) RFBs that provide members with scientific and management advice; (iii) scientific bodies that provide scientific information and advice; and (iv) other IGOs with a responsibility for regional sea turtle conservation.

Illegal, unreported and unregulated (IUU) fishing may pose a threat to sea turtles because IUU vessels are unlikely to employ measures to reduce sea turtle interactions and mortality. While it is beyond the scope of this report to review IGO measures to address IUU fishing, several RFBs have taken steps to effectively reduce IUU fishing, including instituting requirements for vessel monitoring systems (VMS), managing lists of authorized (approved) and illegal vessels, port and at-sea inspection programmes and trade documentation programmes.

Guidelines for marine capture fisheries to reduce sea turtle interactions and mortality

One way to mitigate fisheries interactions with sea turtles is to avoid them; however, this may be problematic as the same productive areas conducive to fishing are attractive feeding grounds for sea turtles.
However, there is a wide range of management and technical methods developed by researchers, industry, and fisheries administrations that may be used to reduce sea turtle interactions and mortality in marine capture fisheries. The methods are categorized according to the type of fishery to which they are suited, and the advantages and disadvantages of each method are summarized for ease of reference.

Examples of methods that can help to reduce sea turtle interactions and mortality in marine capture fisheries include:

- modifications to fishing gear (including bait) and fishing methods;
- post-capture practices that can improve the survival prospects of sea turtles after release;
- area restrictions or seasonal restrictions on fishing operations;
- voluntary communication between the fishing fleet to avoid sea turtle hotspots;
- input controls, such as controlling the type or amount of fishing;
- output controls, such as limiting the catch through, for example, total allowable catch (TAC) or quotas;
- imposition of a bycatch fee or other compensatory methods;
- avoiding the loss and discarding of fishing gear and other debris; and
- retrieving derelict fishing gear and other debris at sea.

It must be noted that all technical measures, modification of fishing gear and/or other management measures must be adapted to the conditions of areas, vessels and gear used. There is no “one size fits all solution” in mitigation measures!

Table 1. Summary of methods used to reduce sea turtle interactions and increase the likelihood of turtles surviving interactions with marine capture fisheries

Measure to reduce sea turtle interactions or injury	Empirical evidence of turtle avoidance efficacy	Empirical evidence of economic viability	Evidence of practicality
Multiple fisheries			
Handling and release practices	Y	Y	Y
Time–area closures/marine protected areas (MPAs)	N	Y	Y
Fleet communication for real-time bycatch hotspot avoidance	Y	Y	Y
Limited entry	Y	Y	Y
Limit on effort	Y	Y	Y
Sea turtle interaction cap per fishery or per vessel	Y	Y	Y
Bycatch fees or other compensatory mitigation measures	N	N	N
Target species catch limit	Y	Y	Y
Reduction of derelict fishing gear and other marine debris	N	Y	Y
Changing gear type to one with a lower turtle bycatch to target catch ratio	Y	Y	Y
Gillnet fisheries			
Lower-profile (narrower), stiffer nets	Y	Y	Y
Deeper setting for surface gillnet fisheries	Y	N	Y
Use longer tie-downs or avoid their use in demersal gillnets	Y	Y	Y
Avoid exceeding a maximum threshold for mesh size	N	N	N
Pelagic longline fisheries			
Replacement of J and tuna hooks with wider circle hooks	Y	Y	Y
Use of fish instead of squid for bait	Y	Y	Y
Setting gear deeper	N	Y	Y
Use of dyed bait/camouflaged gear	N	N	Y
Reduced gear soak time, e.g. increasing number of sets per day	Y	N	Y
Avoidance of fishing in certain sea surface temperatures	Y	Y	Y
Use of intermittent flashing light sticks in place of traditional continuous flashing light sticks and not using luminous gear	Y	N	Y
Coastal trawl fisheries			
Turtle excluder devices for shrimp fisheries	Y	Y	Y
Purse seine fisheries			
Avoidance of encircling sea turtles	N	N	N
Modified designs for fish aggregating devices (FAD)	N	N	N
Demersal longline fisheries			
None			

Table 1 summarizes the various methods used to reduce sea turtle interactions in marine capture fisheries. It is important to note that the efficacy and commercial viability of some strategies will be fishery-specific; an indication of success in Table 1 does not mean that a measure will necessarily be effective across all fisheries. Further investment may also be necessary to bring these methods to a state where they are commercially viable.

It is necessary and beneficial to have direct industry involvement in the development of fishery-specific sea turtle bycatch solutions because:

(i) Fishers are likely to have valuable knowledge and information relating to sea turtle bycatch. Their knowledge can be helpful in finding effective and practical solutions. This has been demonstrated through a number of cooperative research initiatives, such as in the United States Atlantic longline swordfish fishery, the Hawaiian longline fishery, as well as various industry-led fleet communication protocols aimed at reducing bycatch.

(ii) While lessons learned in other fisheries will provide a useful starting point, solutions to sea turtle bycatch problems may be fishery-specific. Some of the factors that need to be taken into account when adapting bycatch solutions are the size and species of turtle, the target species, vessel size and design, fisher safety aspects, etc.

(iii) It is necessary to consider a method's effectiveness at reducing turtle capture and injury, as well as its commercial viability. Methods that are shown to be effective in reducing turtle bycatch in experiments may not be employed as prescribed, or employed at all, if they are not convenient and economically viable, or better yet, provide operational and economic benefits to fishers.

By ensuring the direct participation of fishers in the development and testing of bycatch avoidance methods, one is more likely to encourage a feeling of ownership within the fishing industry and thereby achieve support, broad uptake and effective use of the method.

Fishing gear designs and fishing methods

Gillnet fisheries

A gillnet is a curtain of netting that hangs in the water at various depths, suspended by a system of floats and weights, or anchors. The netting is almost invisible to fish as they swim into the gillnet. Fish may become entangled, enmeshed or gilled in these nets. The size of gillnet meshes (common are meshsizes between 5–40 cm, depending on target species) determines the size of the caught fish. Small meshes will catch small fish like sardines, but for larger species there is always a danger of becoming entangled in such nets. Gillnets with larger meshes, designed to target large pelagic species or cod or salmon, will allow small fishes to go through the meshes. Gillnets are considered size-selective gear in relation to target species, but they are non-selective for marine mammals, seabirds and turtles.

One special type of gillnet, the pelagic drift nets on the high seas, target species such as swordfish and other billfish, sharks, mackerels and mahi mahi. Sometimes drift nets are lost and turn into "ghost nets" that can trap marine life for a certain time. However in most cases, lost pelagic gillnets collapse soon after deployment and form bundles of nettings in which relatively few fish or other marine organisms are caught. Therefore, the threat of lost pelagic gillnets to marine turtles is low.

Coastal bottom gillnets are often set close to shore or laid atop reef flats, a primary sea turtle feeding area. Turtles entangled in these nets face a high risk of drowning.

In some demersal gillnet fisheries, tie-down ropes are typically used to maximize the catch of demersal fish species. Tie-downs are lines that are shorter than the fishing height of the net and connect the float and lead lines at regular intervals along the entire length of the net. This modification creates a bag of slack webbing that aids in "entangling" rather than "gilling" demersal fish species. Unfortunately, this technique also poses an entanglement hazard to sea turtles that encounter the gear. Several studies in North Carolina's flounder gillnet fishery found that lower profile nets without tie-downs significantly reduced the incidence of sea turtle entanglement compared with traditional gillnets that contained twice as much webbing and contained tie-down ropes regularly placed throughout the gear. Research has also demonstrated that entangled turtles have a higher rate of escape when longer tie downs are used (Figure 6a–b).

Figure 6a. Gillnet equipped with tie-downs (turtles can become entangled)

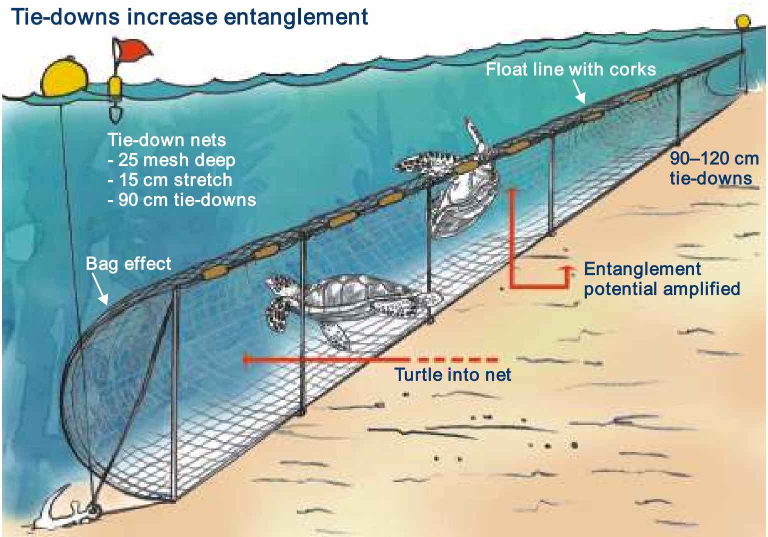
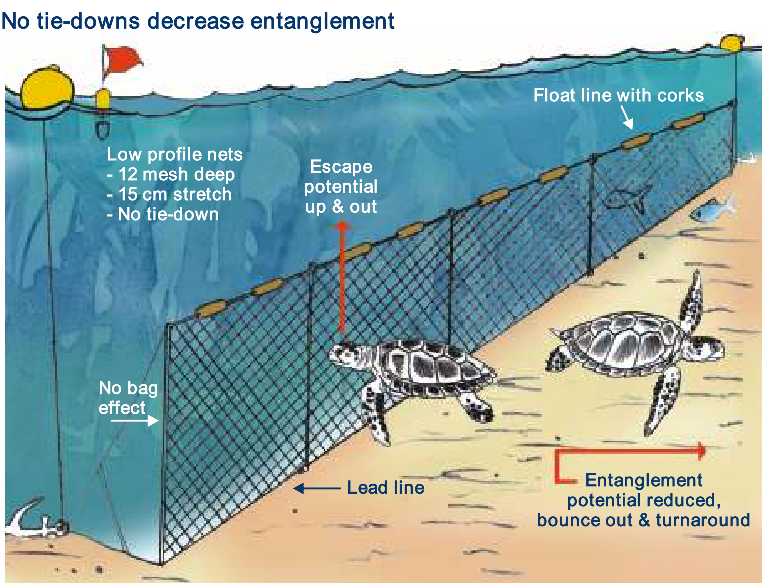


Figure 6b. Gillnet with longer tie-downs (turtles can escape more easily)



In demersal gillnet fisheries, there is empirical evidence that the use of narrower (lower profile) nets is an effective and economically viable method for reducing interactions with sea turtles. This is due to the combined effect of the net being stiffer, thereby reducing the entanglement rate of turtles that encounter the gear, and the net being shorter, thereby reducing the proportion of the water column that is fished and so reducing the likelihood of turtles encountering the fishing gear. Furthermore, increasing tie-down length, or avoiding the use of tie-downs, has also been shown to decrease turtle entanglement rates.

The low profile technique has also proved effective at reducing turtle interactions in surface gillnet fisheries. Again, using lower profile nets reduces sea turtle entanglement as a result of the net being stiffer and reducing the proportion of the water column containing gear. Recent research in the Trinidad surface drift gillnet fishery for mackerel demonstrated a 35 percent reduction in leatherback bycatch rates through the use of lower profile nets. Catch rates of target species were not significantly compromised.

The following have been suggested as potential strategies for avoiding sea turtle entanglement in gillnet fisheries. However, all of these strategies require additional testing:

- Deeper setting may reduce turtle captures by avoiding the upper water column where turtles are most abundant. However, experience has shown that deeper setting may result in unacceptable reductions in the catch rates of target species.
- Using alternative net materials to reduce the risk of turtle entanglement.
- Setting nets perpendicular to the shore to reduce interactions with nesting females.
- Using deterrents, including sonic “pingers”, shark silhouettes, lights or chemical repellents.
- Management approaches such as area or seasonal closures should also be considered as a means of reducing turtle interactions in gillnet fisheries. For these measures to be efficient, good information on seasonal patterns in the distribution of sea turtles is required.

Further reading on sea turtle gillnet and pound net fisheries interactions

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Pelagic longline fisheries

Pelagic longlining is a commercial fishing technique that ranges in scale from domestic artisanal fisheries to modern, industrialized fishing, which is often conducted by distant water fishing nations (Figure 7).

Main target species are large tunas (*Thunnus* spp), swordfish (*Xiphus gladius*), other billfishes (species of the family Istiophoridae), and dolphinfish (mahimahi, *Coryphaena* spp). Longlines can be set to hang at varying depths depending on the targeted species.

Figure 7. Pelagic longlining occurs throughout the world's oceans. This method of fishing has been used since the nineteenth century and ranges from small-scale domestic artisanal fisheries using small and sometimes open vessels (the top-left photograph shows small boats from Peru's artisanal pelagic longline fleet), to modern mechanized industrial fleets from distant water fishing nations. The top-right photograph shows medium-sized longliners at Pago Pago, a port in American Samoa, while the bottom photograph shows a Japanese distant water pelagic longliner.

Pelagic longline fleets use a range of different fishing practices and gear configurations. Longlines commonly consist of a long main line from which individual hooks are suspended at intervals of 80–120 m. They can be up to 100 km long and carry up to 3 500 barbed hooks. The hooks are attached to the main line by monofilament branch-lines or gangions. Floats spaced along the main line keep it elevated horizonally in the water, and the branch lines hang vertically from it (Figure 8a–b). A variety of bait is used, with whole smaller fish, such as Atlantic mackerel and squid.

Figure 8. Generalized configuration of drifting longline.
(Lengths and material of floats, main and branch lines; number of hooks between floats; number and placement of weights on branch lines type of hooks and bait and methods of setting and hauling vary between fisheries and vessels in a fishery.)

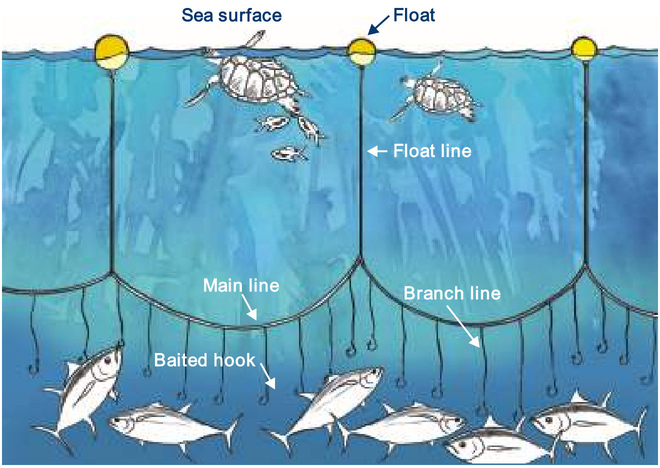


Figure 8a. Long float line results in deeper settings

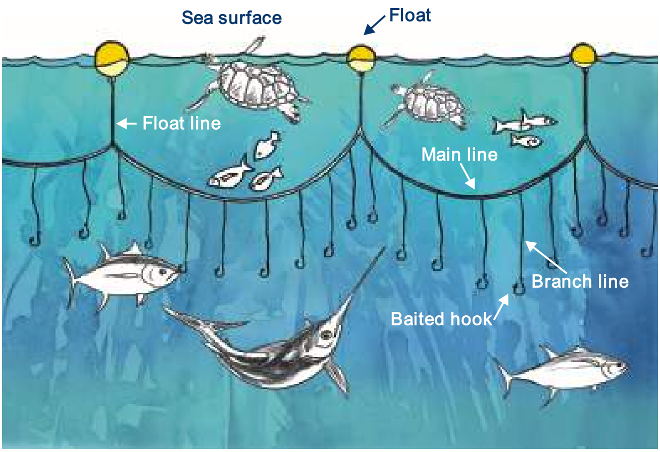
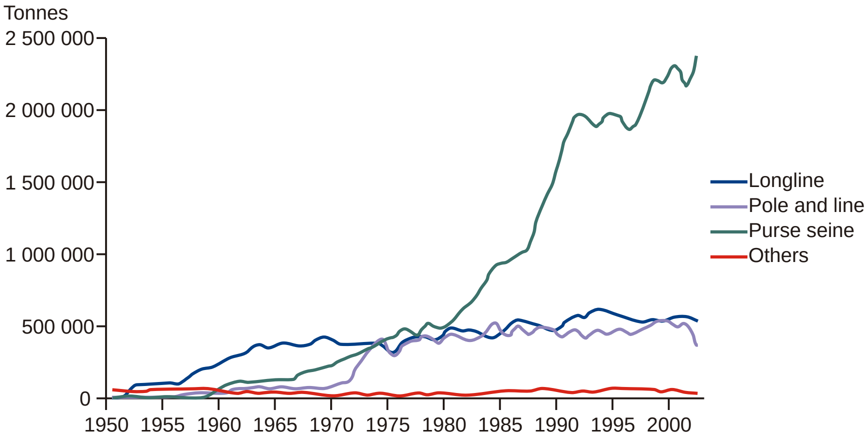


Figure 8b. Short float line results in shallower settings

In 2002, purse seine fisheries caught about 58 percent of the total combined weight of the principal market species of tunas. Longline fisheries caught 15 percent, pole-and-line fisheries 14 percent, "other" fisheries (coastal artisanal gillnet, handline, etc.) 13 percent, and troll fisheries less than one percent (Figure 9). Large longline vessels (> 24 m in overall length), including those with freezer technology, target bluefin and bigeye tunas for the *sashimi* market. Total catch by large longliners has been stable or slightly decreasing since the late 1990s, while catches by smaller coastal longliners (< 24 m in overall length) have been increasing since the 1990s.

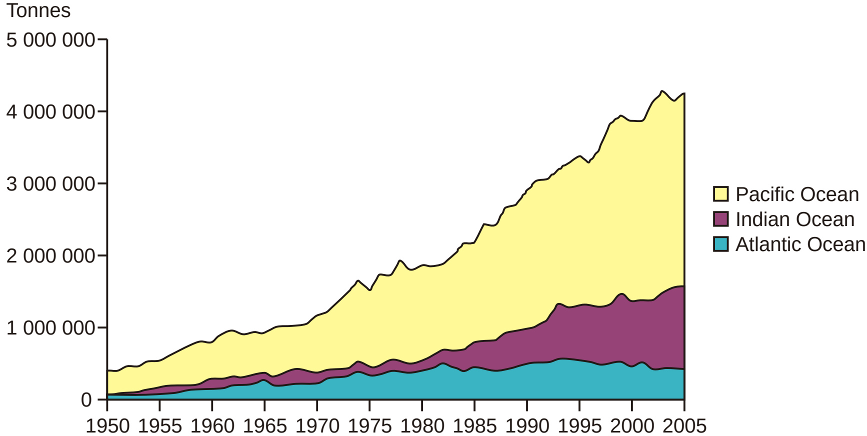
Figure 9. Trends in weight of world reported landings of principal market species of tunas by fishing gear type (redrawn and updated from Bayliff, Moreno and Majkowsky, 2005)



Catches from the Atlantic, Indian and Pacific Oceans produce about 10, 23 and 66 percent, respectively, of the total catch of the principal market species of tunas (Figure 10). Increased catches of tropical tunas, primarily yellowfin and skipjack, but also bigeye, by purse seine vessels, account for the majority of the observed increased trend in total tuna landings.

All sea turtle species are affected by pelagic longlines, but the loggerheads and leatherbacks are the most frequently caught species.
Several attempts have been made to quantify the number of sea turtles accidentally caught in fishing operations every year. These studies usually apply to specific areas and fisheries and are, therefore, poorly suited to extrapolate global estimates. For example, in 2004, one study estimated that more than 200 000 loggerheads and 50 000 leatherbacks were taken as bycatch in pelagic longline fisheries in 2000.

Figure 10. Trends in reported landings of principal market species of tunas by ocean (redrawn and updated from Bayliff, Moreno and Majkowski, 2005)



However, it is likely that these numbers were overestimated because several incorrect assumptions were made when extrapolating Hawaiian observer data to foreign fishing fleets operating in the Pacific.

Turtle catch rates from swordfish and tuna vessels vary widely between fisheries and even between vessels operating in the same fishery. For example, catch rates range from zero to 14 loggerheads and from zero to 2.4 leatherbacks per 1 000 hooks. The Pacific-wide catch rate for leatherbacks is estimated to be 0.0275 turtles per 1 000 hooks (this figure is based on 20 000 leatherbacks caught on 728 million hooks). However, estimated catch rates are affected by the fact that individual turtles may be captured multiple times. This phenomenon results in the overestimation of sea turtle mortality. For example, a study of the Italian fishery for swordfish in the Mediterranean Sea revealed that 92 percent of caught loggerheads had one or more hooks either lodged externally or internally (internal lodging was revealed by x-ray analysis). Some turtles had as many as three hooks lodged in their stomachs.

Swordfish are typically caught in shallower waters than tunas and therefore a priority is to employ sea turtle avoidance methods that are effective and commercially viable for use in fisheries targeting swordfish. Furthermore, the distant water fishing fleets of Taiwan Province of China, Japan and Spain landed the largest catches of swordfish in 1997. Together, these fishing nations account for more than half of global swordfish landings.

While large, industrialized pelagic longline fleets from distant water fishing nations are believed to have relatively high sea turtle mortality rates, some coastal artisanal and small domestic longline fleets that set shallow gear may also cause relatively high sea turtle mortality and thereby affect populations of critically threatened turtles. This is as a result of the location of their fishing grounds and their fishing methods and gear. For example, in Ecuador, the artisanal longline fisheries for dolphinfish, swordfish and bigeye tuna use relatively small J hooks and tuna hooks and set their fishing gear at shallow depths. The fishing grounds overlap with high densities of east Pacific leatherback turtles and olive ridley turtles. These turtles migrate through waters around the Galapagos Islands after nesting in Mexico and Costa Rica. Another example is provided by the longline dolphinfish surface fishery in Costa Rica where olive ridley turtle capture rates are very high. Similarly, high numbers of interactions between leatherback and loggerhead turtles and the Peruvian coastal, artisanal, longline dolphinfish and shark fisheries have been documented. Owing to the distribution of the world's most threatened sea turtle populations, the pelagic longline fisheries of the eastern Pacific and Mediterranean also represent a serious threat to turtles.

There are several fishing methods and gear modifications that have been shown to reduce sea turtle interactions in longline fisheries significantly without compromising catch rates of target species. These methods include:

(i) using wide circle hooks;
(ii) using fish rather than squid for bait; and
(iii) setting hooks deeper than turtle abundant depths (40–100 m).

Other strategies are currently being tested. These include:

(i) using relatively small circle hooks (= 4.6 cm narrowest width) in place of narrower J and tuna hooks;
(ii) single hooking fish bait rather than threading the hook through the bait multiple times;
(iii) reducing gear soak time and retrieving gear during daytime; and
(iv) avoiding bycatch hotspots through fleet communication programmes and area and seasonal closures.

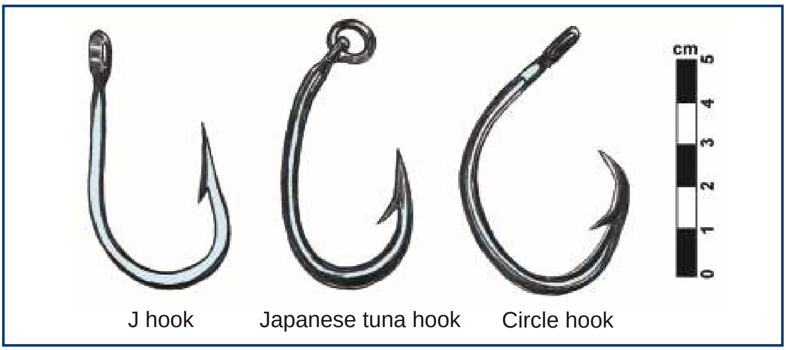
Different fisheries show different results

The effectiveness and commercial viability of a turtle avoidance strategy may be fishery-specific. Its success may depend on the size and species of turtles, the target species and other variables. It is therefore advisable to test sea turtle avoidance methods in individual fleets and regions.

Circle hooks and fish bait

Circle hooks, J hooks and tuna hooks are three types of hooks in use in pelagic longline fisheries. A circle hook is rounded with the point oriented perpendicular to the shank, while a J hook is shaped as its name implies, with its point oriented parallel to the hook shaft. In shape, a tuna hook is in between a circle and a J hook, but the point of the tuna hook is not guarded by the shaft, as is the case for J hooks (Figure 11). The point on a circle hook is turned in, towards the hook shank.

Figure 11. Main types of hooks used by longliners



Experiments suggest that circle hooks are effective at reducing captures of hard-shelled turtles because they are wider at their narrowest point than J hooks and tuna hooks. Therefore, they are too wide to fit into the mouths of sea turtles. The circle hook may also be effective at reducing leatherback captures because of its shape; hard-shelled turtles tend to become caught in longline gear because they bite a baited hook, while leatherbacks tend to become caught because they are foul-hooked on the body or entangled in the line.

There is a growing number of experiments that provide information about the effects of hook and bait combinations on both sea turtle capture rates and target species catch rates in pelagic longline fisheries. For example, in the United States North Atlantic longline fishery for swordfish, the use of 18/0 circle hooks and squid bait reduced loggerhead and leatherback bycatch rates by 86 percent and 57 percent, respectively compared with fishing with J hooks and the same bait. When combined with mackerel bait (rather than squid bait), the 18/0 circle hook reduced loggerhead and leatherback bycatch rates by 90 percent and 65 percent, respectively, without compromising catch rates of swordfish. Similar results have been observed in the Hawaiian longline swordfish fishery: capture rates of leatherback and loggerhead turtles declined substantially – by 83 percent and 90 percent respectively – after switching from a J hook with squid bait to a wider circle hook with fish bait.

In addition to reducing sea turtle capture rates, the use of circle hooks has been shown to reduce the number of turtles that are deeply hooked, i.e. the hook is swallowed into the oesophagus or deeper, rather than being hooked in the mouth or foul hooked on the body. Mouth-hooked turtles probably have a greater chance of surviving a hooking than deeply hooked turtles (Figure 12a–c).
Moreover, gear removal is more commonly accomplished with lightly hooked turtles. For example, in the United States North Atlantic longline fishery for swordfish, the use of circle hooks rather than J hooks substantially reduced the proportion of deeply hooked sea turtles landed by the fishery. Similar effects were observed in the Hawaiian longline swordfish fishery; after switching from J hooks

Figure 12a–c. Examples of hooking and entanglement

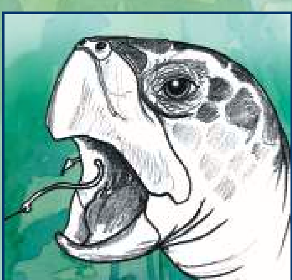


Figure 12a.
Mouth-hooked turtle

Figure 12b.
Deeply hooked turtle
(hook swallowed in the stomach)

Figure 12c.
Entangled turtle

and squid bait to wider circle hooks and fish bait, there was a significant reduction in the number of turtles that swallowed hooks (into the oesophagus and deeper) and a significant increase in the numbers of turtles that were released after the removal of all terminal tackle, both of which are outcomes that may increase the likelihood of turtles surviving the interaction.

In some fisheries, the use of circle hooks and fish bait has been shown to improve catch rates of certain target species. For example, after a requirement was instituted for vessels in the Hawaiian longline fishery for swordfish to use 18/0 circle hooks with fish bait – in place of 9/0 J hooks with squid bait – the swordfish catch rate increased significantly by 16 percent. However, catch rates of combined tuna species and catch rates of combined mahimahi, opah, and wahoo declined significantly, by 50 percent and 34 percent, respectively. Similar results were observed in the United States Atlantic longline swordfish fishery. The reduction in catch per unit effort (CPUE) for tuna species is likely due to the size of the fish bait being used in these fisheries. Other studies have shown increases in CPUE for tuna species when circle hooks were used in combination with smaller sized fish. Reduced CPUE for the other fish species is likely due to the size of the circle hook used.

Different shapes show different results

Circle hooks come in a variety of shapes and sizes. Different shapes can change the performance of individual hooks. For example, a circle hook with a larger gap between the point and the shank, or greater than a 10° offset, may affect the hook's interactions with sea turtles.

Other differences in hook designs, such as the material from which the hook is manufactured, may also affect sea turtle capture rates and position of hooking. Unfortunately, there is no uniform system of hook measurements. This is problematic when reporting research results and comparing results between experiments and may be compounded by the fact that the different manufacturers of hooks use different terminology.

Furthermore, several studies have demonstrated that switching from squid to fish bait results in large (approximately 35 percent) and significant reductions in shark catch rates. The effect on shark catch rates when switching to a circle hook from J and tuna hooks is unclear, with conflicting results from different studies.

Offset hooks

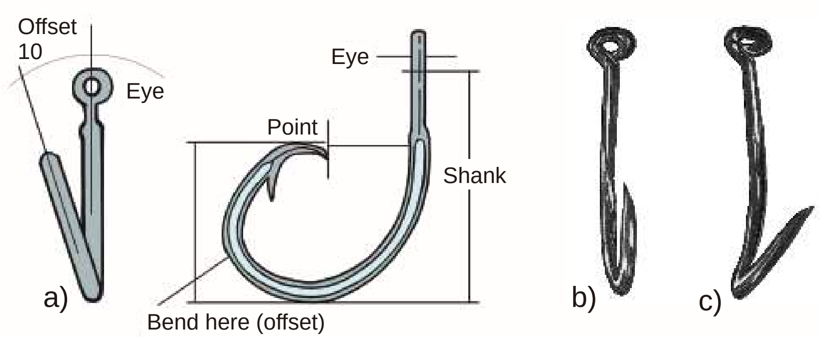
Offset circle hooks are similar in shape to non-offset circle hooks, but the point is not in line with the shank (Figure 13a–c). When laid on a flat surface, a non-offset hook would lie flat, but the point of an offset hook would be slightly elevated. Research has shown that using offset circle hooks with 10 degrees or less offset, rather than non-offset circle hooks in longline fisheries, does not affect sea turtle capture rates. Furthermore, the use of less than 10 degree offset circle hooks does not seem to affect the location of turtle hooking. Circle hooks with more than a 10 degree offset behave similarly to J hooks and increase turtle capture rate and increase the proportion of caught turtles that are deeply hooked when compared with non-offset circle hooks. It may be possible that offset hooks result in increased injury to turtles relative to non-offset hooks when a hook is ingested because the offset hooks may be more likely to embed internally instead of passing through.

The use of circle hooks results in less foul hooking than J hooks. Leatherbacks are most often foul hooked; it is likely that any size circle hook with minimal offset will result in a reduction in leatherback bycatch.

The influence of bait

Turtles have been observed to feed differently when feeding on squid and fish. Observations of foraging captive turtles reveal that they tend to eat fish progressively, in small bites, until they completely remove the fish from the hook (Figure 14a). However, turtles tend to line up squid with their flippers and gulp it down whole, ingesting the hook and bait together (Figure 14b). This is possibly because the flesh of squid is firmer and more rubbery than fish, and turtles may have difficulty biting off pieces of squid.

Figure 13a. Generic outline (frontal and lateral view) of a circle hook to show main parts and how the offset angle is measured; **b.** example of non-offset hook (point of the hook in line with the shank); **c.** example of offset hook (point of the hook not in line with the shank)



Although there is a need for additional research, some studies have shown that bait type and size can have an effect on sea turtle interactions. For example, several studies have shown that turtle capture rates decreased when mackerel or sardine was used as bait in longline fisheries instead of squid bait. It is hypothesized that using larger bait may make it more difficult for turtles to swallow the bait and, therefore, the hook. However, this remains to be tested.

Summary of main advantages and disadvantages of using circle hooks and fish bait in longline fisheries

Bycatch avoidance method	Advantages	Disadvantages
Use of circle hooks	- Significant reductions in sea turtle catch rates - Significant reduction in the proportion of caught turtles that are deeply hooked - Possible higher catch rates of swordfish	- Possible lower catch rates of certain target and commercially important incidental species - Possible increase in shark catch rates - Fishery-specific testing is required to assess efficacy, both for avoiding turtles and to test economic viability
Use of fish bait instead of squid bait	- Significant reductions in sea turtle catch rates as well as shark catch rates	- May have an adverse effect on economic viability in some fisheries

Figure 14a. Fish bait is eaten in small bites

Figure 14b. Squid bait is gulped down whole because of its firm and rubbery structure

Deeper setting

Turtles usually occur at depths of less than 40 m

Several studies have shown that sea turtles spend the majority of their time at depths of less than 40 m. For the most part, the diving behaviour of loggerhead and olive ridley turtles is restricted to the upper 100 m of the water column and although leatherbacks can dive much deeper – to 900 m – a large proportion of their time is spent in the upper 200 m of the water column. The average dive depth of leatherbacks is estimated to be 61.6 m and they forage at night on the deep scattering layer (DSL) when it is nearer to the surface. The DSLs is a concentrated layer of marine organisms found in most oceanic waters that reflects and scatters sound waves, as from sonar. DSLs are of varying composition and can include both plankton and nekton, i.e. free-swimming organisms such as copepods, krill and small fish, and may occur at more than one depth in the same location. Typically, they move upward at night to feed on phytoplankton and downward during the day, as deep as 1 000 m, probably to escape predators.

Although the depths at which turtles forage is generally known, empirical evidence that demonstrates the effectiveness of setting longline gear deeper to avoid interactions with turtles is currently lacking. This is a research priority. However, there is evidence that deep-set longline fisheries have lower turtle catch rates than shallow-set fisheries.

The effect of deeper setting on the catch rate of target species in pelagic longline fisheries is fishery-specific. For example, in certain fisheries it may not be commercially viable to set gear deeper than 100 m, but for others, it will be feasible to set gear deeper with no noticeable change in the catch rates of target species. For example, tuna gear is typically set below turtle-abundant waters, while some swordfish gear is likely to be set at depths where turtles are abundant.

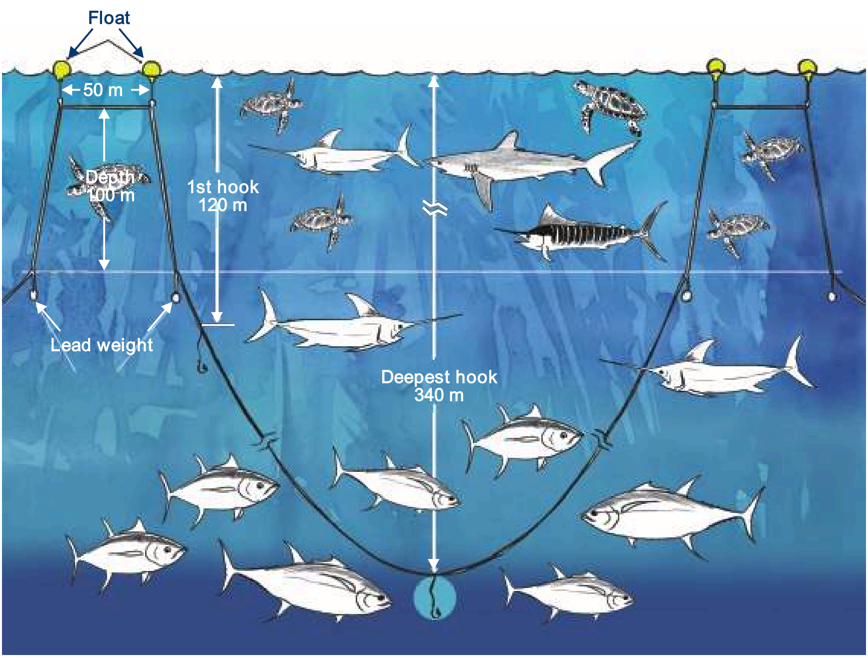
In longline fisheries where it is economically viable to set gear deeper than 100 m, a minimum precaution is for vessels to use longer branch lines adjacent to the buoys; these are effectively the shallowest set hooks. An alternative is to leave a gap on each side of the buoy line. Longliners should be encouraged to minimize all gear between zero and 100 m to reduce the risk of entangling turtles. This can be accomplished by increasing the length of buoy lines rather than having short buoy lines and longer branch lines.

Three promising strategies have been developed to reduce the number of shallow hooks in deep-set gear. One strategy uses lead weights and paired floats to remove the entire fishing portion of the line out of the range of turtles. The second uses a combination of lead weights and mid-water floats to standardize the depth of branch lines (Figure 15). The third uses mid-water floats attached to the main line to ensure that hooks are placed at the same depth, as opposed to having the hooks suspended in a catenary curve.

More turtles drown on deeper-set gear, but fewer turtles are caught

It is important to note that, although there is the potential for the interaction rate with sea turtles to be much lower with deeper-set gear, the mortality rate of turtles caught in deep-set gear is higher. Turtles caught in deep-set gear may drown before the gear is hauled, whereas turtles caught in shallow-set gear are typically alive when gear is retrieved.

Figure 15. Configuration of weighted gear with 20 hooks per basket and a target depth for the shallowest hook of 120 m. Examples of possible target and bycatch species are shown: above 100 m these include sea turtles, sharks and some billfish while below 100 m they include bigeye tuna and day-swimming broadbill swordfish. All baited hooks are below the 100 m line (after Beverly and Robinson, 2004).



Summary of main advantages and disadvantages of setting gear deeper than 100 m in longline fisheries		
Bycatch avoidance method	**Advantages**	**Disadvantages**
Setting longline gear deeper than turtle abundant waters, i.e. deeper than 100 m.	- Substantially fewer sea turtle interactions (sea turtle bycatch rates are higher by an order of magnitude in shallow-set pelagic longline fisheries)	- May not be economically viable for all longline fisheries - Turtles caught in deep-set gear may drown before gear is hauled

Dyed bait

Bait that is dyed blue has not been shown to result in a significantly lower sea turtle capture rate than untreated bait. This is based on research from longline fisheries in the United States of America, Costa Rica and Japan, as well as on captive green and loggerhead turtles. Furthermore, owing to the expense of dyeing bait and given fishers' perceptions that dyeing bait is impractical, industry acceptance of blue-dyed bait is expected to be low, unless competitively priced pre-dyed bait becomes commercially available.

Soak time

One study found the effect of total soak time (the period that fishing gear is in the water) to have a highly significant effect on loggerhead catch rate. The effect of daylight soak time was varied and inconclusive. Another study documented a significant increase in loggerhead capture rate with increased length of daytime line hauling. For leatherbacks, neither daylight nor total soak time had a significant effect on leatherback catch rates. However, research with hook timers indicates that leatherbacks are hooked more frequently at night. Overall, this limited body of research suggests that reducing total soak time and daytime retrieval can reduce loggerhead capture, while reducing the amount of time gear is in the water at night might reduce leatherback catch rates.

Other gear technology strategies

- **Water temperature** has been shown to play a role in sea turtle bycatch rates. Pelagic longliners use an array of high-tech devices to locate the water temperature "fronts" where the targeted fish congregate, attracted by high prey concentrations. Longline vessel captains use satellite services that provide sea surface and subsurface temperatures, weather faxes, GPS, sonar and radar to help determine the best places and methods to set their gear. It has been shown that loggerhead catch rates increased in sea surface temperatures of greater than 22.2° C; leatherback catch rates increased in sea surface temperatures above 20° C. One study reported that the highest loggerhead catch rates occurred in water temperatures of 23.8°C. In contrast, catch rates for target species showed a different trend. Higher swordfish catches (by weight) occurred in water temperatures of below 20° C. Therefore, for some fisheries, a promising strategy might be to fish in water temperatures of less than 20° C. This might have the effect of decreasing sea turtle interactions with longline fishing gear, while at the same time increasing catch rates for target species.

- Preliminary research indicates that **single-hooked fish baits on circle hooks** may result in higher catch rates for swordfish – and a lower incidence of loggerhead turtles swallowing the baited hook – than when the circle hook is threaded through the fish bait multiple times. However, further studies are required to test this method.

- Turtles may be attracted to some types of **light sticks**, which are a standard component in longline fisheries that target swordfish. They may also be attracted to luminous beads or loop protectors that are used in some longline fisheries. One study showed that the highest CPUE for leatherbacks in the Atlantic longline fishery was on sets using light sticks. Another study showed that the highest CPUE for loggerheads in the Canadian longline fishery was on sets using luminous protectors. A study of captive loggerhead turtles found that light sticks that flash intermittently did not attract loggerhead turtles.

A small commercial demonstration of "stealth" gear designed to be less detectable by turtles included gear with:

- light sticks shaded on the upper half;
- light sticks with narrower light frequency;
- counter-shaded floats (blue on the bottom half, orange on the top half);
- dark grey lines;
- dulled hardware (painted to remove the metallic shine).

It found that stealth gear was not economically viable in the Hawaiian longline swordfish fishery.

Avoiding the use of conventional light sticks and other luminous fishing gear would likely reduce sea turtle interaction rates. More investment in research and the design of alternative light sticks is needed.

Longline gear modifications under development

A range of gear modifications have been tested to determine their impact on the behaviour of captive turtles. For example, modifications to buoys; avoiding the use of snaps (a clip used to attach the buoy to the line); the use of devices like a funnel or soda bottle above or around the baited hook; and using various colours, stiffnesses, and diameters of monofilament branch lines, have all been tested. More research is needed to further develop these strategies.

- Research into the development of a **floatline** that reduces the likelihood of sea turtles becoming entangled in pelagic longline gear, is planned. The concept for the tangle-free floatline is to construct the line using the same material as conventional floatlines and, by using a combination of floats and weights, ensure that the floatline is kept rigid.

- **Self-releasing hooks**, which were developed for catch and release fisheries for game fish such as salmon, may prove to be suitable for use in longline fisheries, although no tests have yet been conducted.

- Scientists are also testing methods to deter turtles from eating baited hooks. These include **acoustic deterrents** and **soaking bait** in various substances. One research group is attempting to identify shark characteristics that produce avoidance behaviour in captive turtles. However, to date the results of all these studies have been inconclusive.

Modifications to hooks and baits may reduce turtle capture, injury and death. Artificial baits, both odourless and with fish odours, have been tested with a view to identifying what attracts turtles to the hook. Other methods currently under investigation include placing a device near or over the baited hook to physically protect it from turtles. For example:

- "Weedless" hooks have a device that covers the point of the hook and which moves away when a fish bites the hook. Weedless hooks may be effective at preventing the foul hooking of turtles.

- "Whisker" hooks increase the dimension of a hook, making it more difficult for a turtle to swallow.

- "Smart" hooks have a device added to the hook that conceals the point at a shallow depth or in warm sea temperatures, but which moves away from the point when deployed at depth or in colder water. One way to rig a smart hook might be to use a bimetallic strip to cover or expose the hook point according to the temperature of the water in which it is deployed. Currently under development is a modified circle hook to which a short, stiff piece of wire is added, near to the eye of the hook, to increase the hook width, making it more difficult for turtles to ingest. The wire points down at an angle of about 45° to the hook's shank.

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Trawl fisheries

Trawl fisheries are perhaps in the most advanced stage as regards turtle avoidance technologies. The turtle excluder device (TED) developed through a close cooperation between scientists, fishing industry and fishery administration led to a significant reduction in sea turtle bycatch.

TEDs and BRDs work in coastal trawl fisheries

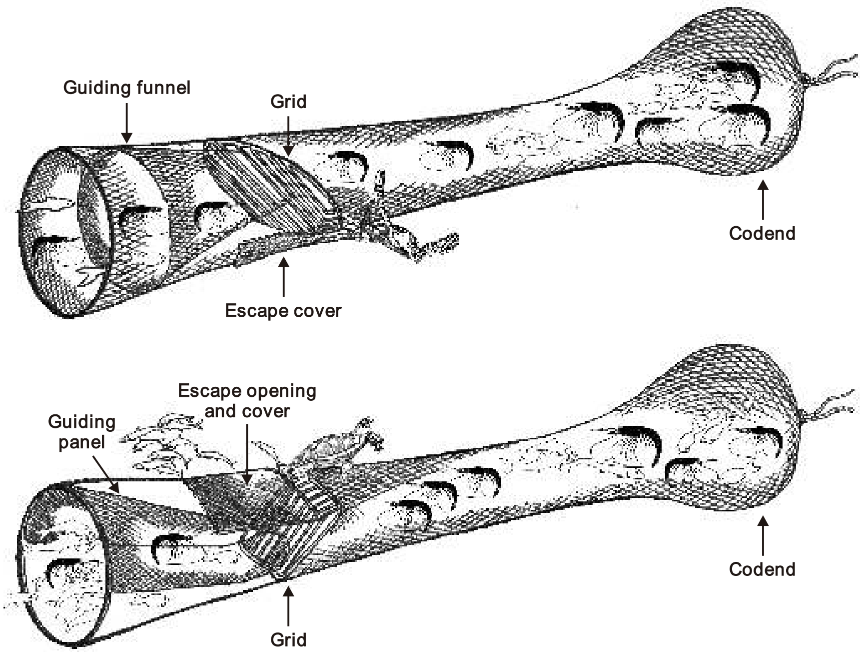
Fisheries that use bottom trawls in coastal waters and other near shore areas – particularly coastal shrimp trawl fisheries – may have a high impact on sea turtles. Considerable research in Australia, the United States of America and later in several other developed and developing countries over more than 20 years has been conducted on gear modifications that reduce turtle bycatch. This research resulted in the development of the turtle excluder device (TED), which reduces the capture of sea turtles and other large animals including sharks, stingrays, jellyfish and some large fish. Bycatch reduction devices (BRDs) that reduce the bycatch of small fish have also been developed. Important progress has been achieved, with empirical evidence showing that a well-designed, properly installed and well maintained TED can exclude nearly all sea turtles that enter a trawl, with an occasional turtle being caught only immediately prior to gear hauling.

The use of TEDs became compulsory in the United States of America in 1989 and has subsequently been introduced to a number of developing and developed countries, partly to enable these fisheries to meet United States rules on shrimp imports.

The FAO encourages the use of TEDs and other measures that are comparable in effectiveness, in shrimp trawl fisheries. In non-shrimp coastal trawl fisheries: (i) data collection is encouraged in order to assess whether sea turtle interactions are problematic; (ii) if necessary, research is encouraged to identify potential methods for reducing sea turtle interactions and sea turtle mortality; and (iii) the implementation of effective turtle avoidance methods that are identified by this research is recommended.

The most common TED designs use an inclined grid to prevent large animals from entering the codend. A guiding funnel/panel of netting in front of the grid may be used to direct animals away from the escape opening and maximize the length of grid available for separating large animals from the shrimp catch. Large animals are then guided by the grid toward an escape opening located either in the bottom of the codend (Figure 16, upper) or in the top of the codend (Figure 16, lower). Small animals (including shrimp) pass through the bars of the grid and enter the codend. The escape opening is a hole cut in the codend and is usually covered with a flap of netting or other material to prevent the escape of shrimp.

Figure 16. The various components typically incorporated into the design of a downward-excluding TED (top) and an upward-excluding TED (bottom)



A less common TED design uses an inclined netting panel instead of a grid. The netting guides large animals toward an escape opening in the top panel of the trawl, while small animals pass through the meshes and enter the codend.

The appropriate design and size of a TED and other bycatch reduction devices (BRDs) is fishery-specific. Several fishery-specific parameters for TED design follow:

- **Size of the escape opening**: The minimum size of the escape opening in TEDs should be based on the length of turtles or other animals that are encountered by a trawl fishery and that are considered to be unwanted bycatch.

- **Grid orientation**: The decision to use a grid that is oriented upwards or downwards will depend on whether rocks, sponges and heavy debris are present on the sea bed of the fishing grounds. Both orientations are equally effective at excluding sea turtles. However, a downward-oriented grid is more effective at excluding rocks, sponges and other debris. A bottom-excluding TED allows the debris to roll towards the escape opening and be excluded, while an upward-oriented grid does not allow these materials to be excluded.
- **TED grid size**: Research in the United States of America and Australia has demonstrated that larger grid sizes improve shrimp retention. This is because a larger grid reduces clogging by increasing the sorting area of the grid. Recent improvements in escape cover designs allow for larger grid sizes and result in improved shrimp retention.
- **Grid angle**: Experience from the United States of America and Australia has demonstrated that a grid angle of 45–55° is optimal for both upward- and downward-oriented grids. This angle ensures the effective avoidance of turtles and other large animals and minimizes the loss of, and damage to, shrimp. Regardless of the grid's orientation, an excessively high grid angle delays the exclusion of turtles and increases the possibility that they will be drowned. It may also result in blockage by rocks, sponges and other debris and hamper the rapid passage of shrimp into the codend. Debris blockage may also partially push the escape opening aside and cause shrimp loss. At the opposite extreme, if the angle of the grid is too low, the escape cover may not sit tightly over the escape opening and shrimp loss is likely to occur. A very low grid angle may also cause the shape of the escape opening to become distorted. However, low grid angles do not appear to affect the exclusion of turtles from the trawl.
- **Bar spacing:** Experience from the United States of America and Australia has demonstrated that grid bar spacing of 100–120 mm for both upward- and downward-oriented grids is optimal. This spacing ensures the effective avoidance of turtles and other large animals and minimizes losses and damage to shrimp. Grid bar spacing is important because it influences the exclusion rate of small or juvenile turtles, as well as the passage of shrimp into the codend. Bar spacing of greater than 120 mm is likely to increase the potential for the head or flippers of large turtles to become fouled in the grid. Smaller grid bar spacing, of less than 100 mm, will have a minimal effect on turtle exclusion and may increase escape rates of fish and other animals. However, it may also increase shrimp loss.

- **Guiding panels or funnels**: Some TED designs include guiding panels or funnels of netting ahead of the grid. These are usually constructed from netting material and are designed to guide shrimp away from the escape opening. However, most Australian and United States trawl shrimp fishers have decided not to use these funnels, and there has been little change in shrimp catches.
- **Netting escape cover**: Most TED designs include a netting escape cover over the escape opening. These are used in all bottom-excluding grids and most top-excluding grids. They help to prevent shrimp from escaping.
- **Grid material**: Grids are typically constructed of aluminium or stainless steel rod or tubing. The latter is preferred in large grids because it provides additional strength and less weight.
- **Grid shape:** The shape of a grid usually fits into one of three categories; rectangular, oval, or a hybrid rectangular and oval grid (”tombstone” grid). Rectangular grids are the simplest to construct and provide a relative large escape opening. A disadvantage of this shape is the risk of netting abrasion at the corners of the grid. Oval grids better conform to the cylindrical shape of the codend and the problem of net abrasion is reduced. Oval grids may also increase the ability of an escape cover to seal tightly over the escape opening and prevent shrimp loss. Tombstone grids can be used so that the square end of the grid provides for a wide escape opening while the opposing rounded end of the grid better conforms to the shape of the codend. In this way, the grid provides a good compromise between rectangular and oval grids.
- **Floats**: Typically, several floats are attached to TEDs to provide buoyancy and stability. This is especially necessary for TEDs with large, heavy grids. Floats are also useful when the gear is at the sea surface because they provide an indication of the orientation of the grid prior to deployment.

TEDs are sold commercially

Various TED designs have been developed and are commercially available. Each has a different shape, size, bar interval and installation angle. In most countries with an important shrimp trawl fishery, like Australia and the United States of America use and design of TEDs are regulated by law.

Hard TEDs

A schematic diagram of the "Super Shooter" TED, an example of a hard TED with a rigid grid is represented in Figure 16. Originally developed for use in the Gulf of Mexico and southwestern Atlantic shrimp fisheries, the Super Shooter also has been tested in the Australian shrimp fishery. The grid has an oval shape and is constructed from aluminium rod or pipe. The bars of the grid are bent near the

Figure 17. Examples of different grids

No safety hazard

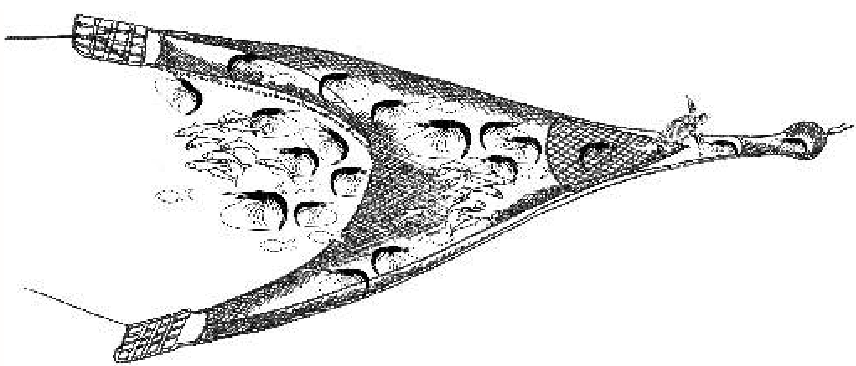
Hard TEDs have been criticized because they were thought to pose a safety hazard to fishing crews, particularly in rough weather. However, these fears have proved to be largely unfounded, if the TED is installed in the right place.

escape opening to facilitate the removal of weed that may foul the bars and prevent the entry of shrimp into the codend. (Although a guiding panel is shown in Figures 16 and 17, it is not used in current designs because of clogging. In the United States of America a guiding panel is now prohibited because it restricts the escape of larger turtles.) Large animals are then guided by the bars towards the escape opening in the bottom of the codend. These animals then push aside a cover located over the escape opening and are excluded from the trawl net. Small animals exit the guiding panel, pass through the bars and into the codend. The escape cover sits tightly against the escape opening and prevents the escape of small animals.

Soft TEDs

Soft TEDs use a non-rigid inclined panel of netting to guide bycatch towards the escape opening in the top of the trawl. Examples of this TED include the Morrison TED (Figure 18), the Parker TED and the "blubber" chute. Soft TEDs have been found to be less effective in excluding heavy sponges and other seabed animals because these foul the netting. Soft TEDs have also been problematic in maintaining turtle exclusion efficiency. The Parker TED is now the only soft TED approved for use in the Gulf of Mexico and southwestern Atlantic shrimp fisheries. The Parker TED does not use the slack, large-mesh webbing that is known to cause turtle entanglements in previously approved soft TEDs. Instead, the Parker TED consists of a single triangular panel, composed of webbing of two different mesh sizes that forms a barrier for turtles inside a trawl and that angles toward an escape opening in the top of the trawl. The Parker TED was tested in a variety of trawl sizes and styles. During testing, the Parker TED successfully excluded 100 percent of the turtles introduced into the trawl, and is especially adaptable under certain environmental conditions; shrimp loss was approximately 9 percent.

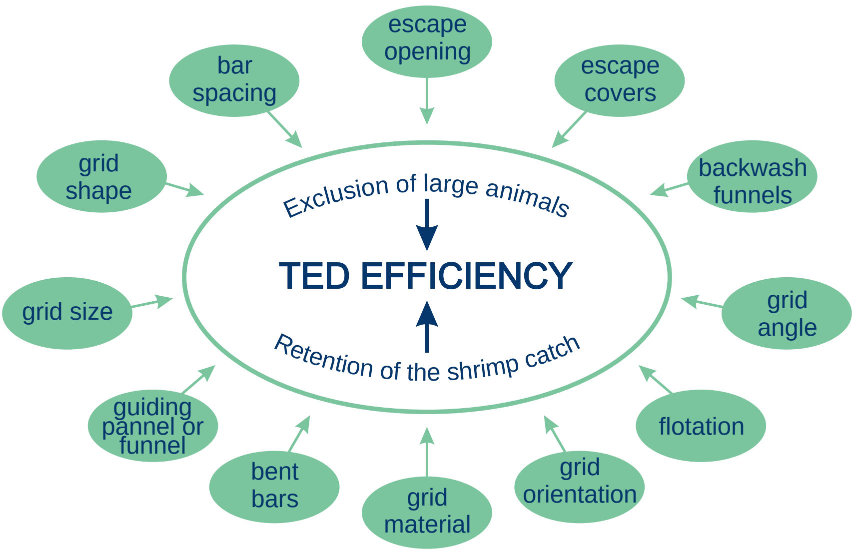
Figure 18. The Morrison TED, an example of a soft TED (after Eayrs, 2007)



Hard TEDs	Soft TEDs
Advantages	
- Very large escape opening may allow large leatherback turtles and other large animals to be rapidly excluded - Exclude some sea bed animals (sponges, corals, etc.) and rocks (downward-excluding TEDs only) - May increase shrimp catch due to longer towing time (less drag and fewer hauls) - May reduce sorting time - May improve shrimp quality by reducing contact with large animals - Reduce hazard to crews from large, dangerous animals	- Very large escape opening may allow large leatherback turtles and other large animals to be rapidly excluded - May increase shrimp catch due to longer towing time (less drag and fewer hauls) - May reduce sorting time - May improve shrimp quality by reducing contact with large animals - Reduce hazard to crews from large, dangerous animals
Disadvantages	
- Damage, fouling or clogging of the guiding panel or funnel by large animals and debris could lead to shrimp loss - Fouling of escape opening by large animals and debris could lead to shrimp loss (a.k.a. TEDed) - A little more difficult to handle than a standard codend - Rigid grid may be a safety hazard to crew (depends on location in codend)	- Poor installation may affect trawl performance - Damage, fouling or clogging of the guiding panel by large animals and debris could lead to shrimp loss - Effectiveness depends on trawl spread - More difficult to repair than a standard trawl - Less effective than hard TEDs at excluding heavy items such as rocks and sponges

TED performance and efficiency are influenced by different combinations of design and construction. An overview of factors influencing TED efficiency are presented in Figure 19.

Figure 19. Factors influencing TED efficiency



In addition to reducing unwanted bycatch of fish, sea turtles, sponges and jellyfish, TEDs provide direct operational benefits to trawl shrimp fisheries by:

(i) reducing catch sorting times;

(ii) reducing damage to shrimp by sharks, stingrays and other large fish species, thereby improving the value of the target catch; and

(iii) enhancing the safety of fishing crews by removing stingrays and sharks from the catch.

Future research and development may well identify superior turtle avoidance methods for trawl gear. There is consensus that contact with a TED and subsequent exclusion does little harm to sea turtles, providing the TED is well maintained and escape occurs quickly. However, what is not well understood is whether there are long-term adverse effects from repeated exclusion of an individual turtle over a short period. It is unclear to what extent escape from a trawl may be delayed by a poorly designed or installed TED without causing severe injury or mortality to sea turtles. Further work is required to evaluate the effect of such incidents on turtle health.

The advantages and disadvantages of using TEDs in trawl fisheries	
Advantages	**Disadvantages**
- Reduce capture of sea turtles - Reduce capture of sharks, stingrays and jellyfish, thereby enhancing crew safety - Reduce damage to shrimp by sharks, rays and other large fish. Therefore, TEDs may enhance catch value - Reduce catch sorting times - May allow fishers to access markets that only sell "turtle friendly" shrimp products	- May require testing and reconfiguration until a fishery-specific practical and viable TED design is identified - May cause injury to sea turtles after repeated interactions with trawl gear

It is important that a TED is well maintained to ensure optimal performance. There are a number of TED components that must be checked and maintained on a regular basis. The following table provides inspection details of these components and the frequency of inspection. If a TED is well maintained, there is no reason why it will not last for several fishing seasons.

Components of TEDs to be checked regularly

Component	Inspection details	Inspection frequency	Suggested action
Guiding panel or funnel	Check for mesh stretch or damage and detachment from codend meshes	Daily	Replace if necessary or re-attach to codend
Grid bars	Bent or damaged bars, bar spacing	Daily	Straighten if possible or replace
Grid angle	Loss of angle	In the first week, daily for new grid, then weekly	Re-attach grid to codend at correct angle
Grid bindings	Check for abrasion, frayed rope strands and loose bindings	Weekly	Replace or retighten if necessary
Escape opening	Damaged meshes adjacent the opening; mesh slippage around frame of grid	Daily	Repair or re-attach adjacent meshes to grid frame
Escape cover	Stretched meshes and attachment to codend	Daily	Replace or re-attach to codend
Backwash funnel	As for guiding panel or funnel	Daily	As for guiding panel or funnel
Floats	Check strong attachment to grid or codend	Weekly	Re-attach to grid or codend

For monitoring the trawl performance and trawl geometry, it would be useful for the industrial shrimp trawl fishery to install some gear control equipment, for example:

- temperatures sensors to obtain information about the temperature at gear position;
- grid sensor, which gives information about the grid angle and speed of the water flow through the grid. User benefits include:
  - making sure the codend is not twisted,

- checking if the grid is mounted with correct angle,
- checking if the grid gets blocked,
- controlling the water speed through the grid.

Other useful sensors for trawl operations are:

- distance sensors, which give information about distance of doors and/or horizontal trawl opening (important when using soft TEDs);
- symmetry sensors that provide continuous information about the trawls' direction in relation to towing direction and underwater currents.

Further reading on sea turtle - trawl fisheries interactions

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Purse seine fisheries

Purse seines are designed to catch schooling fish. A purse seine is made of a long wall of netting framed with a lead line and a float line. The purse seine is set from one or two boats to surround a detected school of fish. A purse line threaded through purse rings spaced along the bottom of the net is drawn tight (pursed) to stop the school of fish escaping downwards under the net.

There are about 570 large-scale (> 383 m^3 holding capacity) purse seine vessels (450 of these operating in the Pacific with a combined carrying capacity of 593 000 tonnes). The number and holding capacity of purse seine vessels has been steadily increasing since the early 1980s. The proportion of the global tuna catch landed by purse seiners exceeded that of the longline and pole-and-line fleets in the mid-1970s and is still increasing (see Figure 9).

Figure 20. Generalized drawing of a purse seine

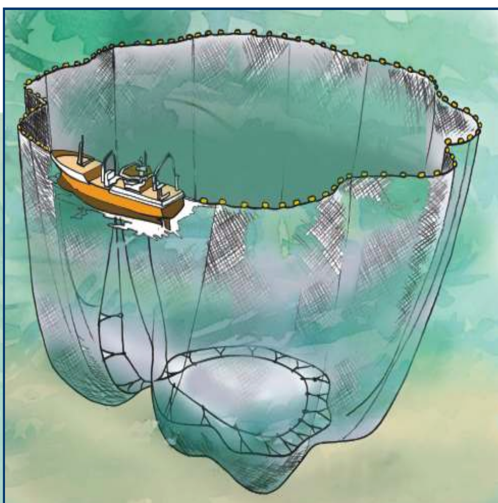

Figure 21. Schematic representation of early purse seining operations showing sea turtles encircled as a bycatch

Sea turtles are occasionally caught in purse seines in the tuna fishery in the Pacific Ocean. Most interactions occur when the turtles associate with floating objects (for the most part fish-aggregating devices [FADs] that offer the turtle diverse prey items and some protection), and are captured when the object is encircled; in other cases, the net may capture sea turtles that happen to be in the location (Figure 21). In these latter cases, the presence of tunas and turtles together may be influenced by oceanographic features such as fronts, but is essentially a chance event: turtles cannot swim fast enough to keep up with tunas or dolphins. Similary as in pelagic longline fleets, the use of satellite services that provide sea surface and subsurface temperatures can also contribute to reducing turtle catch.

Once captured, the turtles may be released unharmed, injured or killed. They can drown if they are entangled for a prolonged time and are unable to reach the surface to breathe. In a few cases, they are lifted out of the water by the fishing gear while still entangled, and may fall from the net at some height and be injured, or may be killed by passing through the power block.

In most cases, turtles are found alive in purse seine nets and can be released over the side of the vessel.

Available information indicates that sea turtle catch rates in Pacific purse seine fisheries are low when compared with interaction rates in gillnet and pelagic longline fisheries.

In the period 1993–2003, the estimated total annual mortalities of sea turtles in the purse-seine fishery, based on observer data from the Inter-American Tropical Tuna Commission (IATTC) was on average 140 individuals, the great majority olive ridley turtles. The recorded mortality of other species is very low: only one leatherback was observed killed during the ten years, and on average, one hawksbill and two loggerheads were killed each year.

A matter of concern is the entanglement of sea turtles in the webbing that fishers frequently attach under FADs to increase their attractiveness and/or visibility. Two options have been proposed to replace the webbing: (a) a series of “kites” tied every few metre to a line hanging under the FAD, and (b) vinyl strips attached to each link of a chain hung under the FAD (in use in some anchored FADs in Hawaii). Experiments to compare the effectiveness of these alternatives should be carried out; for example, the vertical line in the kite system may entangle turtles, and a weighted line or a chain could be used instead.

At the moment, there are several attempts under way to develop mitigation measures that are supported by the fishing industry. As an example, the **IATTC resolutions on bycatch** have been quite successful in reducing mortality. The estimated mortality of sea turtles in the purse seine fishery in 2002, around 46 individuals, is the lowest on record, in spite of a very high level of effort.

Possible mitigation measures recommended to the industry are:

(i) avoid the encirclement of sea turtles, wherever practical;

(ii) if encircled or entangled, take all possible measures to release turtles safely;

(iii) for FADs that may entangle sea turtles, take measures to monitor the FADs and release entangled sea turtles. Recover FADs when they are not in use;

(iv) develop modified FAD designs to reduce and eliminate sea turtle entanglement;

(v) implement successful methods identified through research and development.

If a turtle is caught, the following specific measures should be taken:

(i) Whenever a sea turtle is sighted in the purse seine, all reasonable efforts should be made to rescue the turtle before it becomes entangled in the net, including, if necessary, the deployment of a speedboat.

(ii) If a turtle is entangled in the net, hauling should stop as soon as the turtle comes out of the water and should not start again until the turtle has been disentangled and released.

(iii) If a turtle is brought aboard the vessel, all appropriate efforts to assist in the recovery of the turtle should be made before returning it to the water.

The advantages and disadvantages of turtle bycatch avoidance methods in purse seine fisheries		
Bycatch avoidance method	**Advantages**	**Disadvantages**
Avoid the encirclement of sea turtles	- Reduces sea turtle encounters and time taken to release caught turtles	- Not always feasible
Do not use anchored FADs	- Reduces capture of sea turtles	- May affect on catch rates of target species
Periodically monitor FADs and recover them when not in use	- Allows for the release of entangled sea turtles, avoids entanglement when FAD is not in use	- Requires additional crew time
Conduct research into new turtle-friendly FAD designs	- May reduce capture rates of sea turtles	- Economic cost of designing and testing FADs

Further reading on sea turtle – purse seine fisheries interactions

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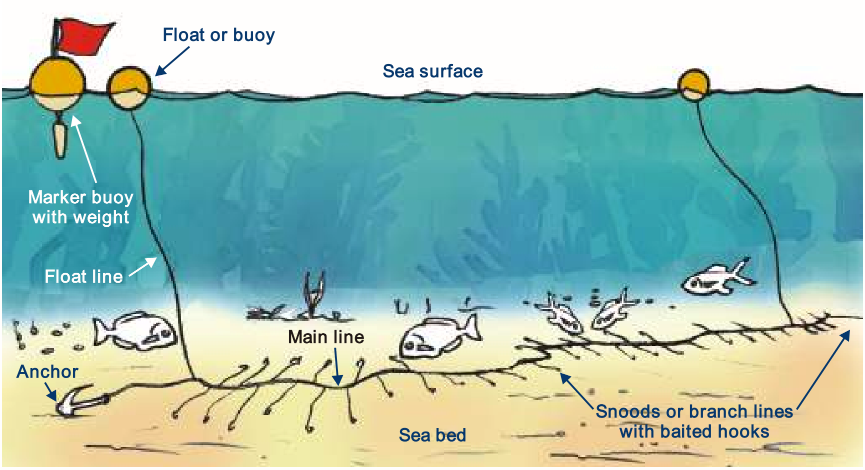
Demersal longline fisheries

Demersal longliners set fishing gear on the sea bed for the purpose of targeting fish species that live at or near the seabed – such as Atlantic cod (*Gadus morhua*) and Pacific halibut (*Hippoglossus stenolepis*). Demersal longline vessels might set up to 40 000 baited hooks per day. Figure 22 illustrates a typical configuration of demersal longline gear.

Evidence of sea turtle interactions in demersal longline fishing is sparse, but there is sufficient evidence to suggest that substantial numbers of sea turtles are caught in some demersal longline fisheries located near turtle nesting sites. For example, an artisanal demersal longline fishery in the Gulf of California, off Mexico, experiences extraordinarily high turtle bycatch and mortality rates. In September 2005, one olive ridley and 26 loggerhead turtles were caught on a total of 1 200 hooks (a catch rate of 21.7 loggerheads per 1 000 hooks). Twenty-two of the 27 caught turtles were retrieved dead, while an additional two died in the boats. This constitutes an 89 percent mortality rate. Similarly, a demersal longline fishery for grouper off Tunisia, reported a moderately high catch rate of 0.278 turtles per 1 000 hooks. Mortality was only 12 percent.

Figure 22. Configuration of demersal longline gear. Lengths and materials of float, main, and branch lines; number of hooks between floats; number and placement of weights on branch lines; depth of gear; types of hooks and bait; and methods of setting and hauling vary between fisheries and between vessels in a fishery.



Like in pelagic longline fishing, changes in hook and bait, i.e. using wider circle shaped hooks with fish bait instead of narrow J hooks with squid bait, may be suitable solutions for reducing demersal longline and sea turtle interactions. Furthermore, in some demersal longline fisheries where turtle interactions are problematic, it may be feasible to modify the gear to enable caught turtles to reach the sea surface and thereby reduce the proportion of caught turtles that drown before gear retrieval. However, research is needed to test these two strategies.

Further reading on sea turtle – longline fisheries interactions

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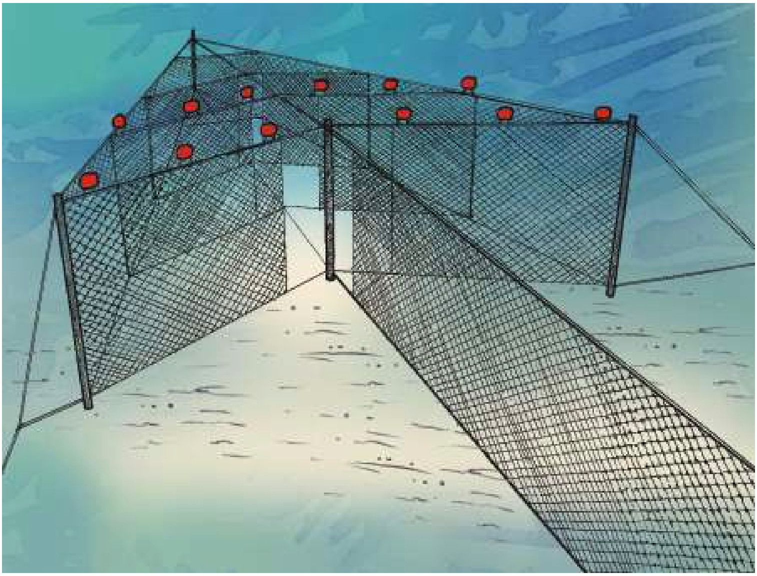
Pound nets/traps

Pound nets are stationary fishing gear and are used to catch a variety of species including striped bass, bluefish, crab, croaker and flounder.

The pound net system is divided into three sections: a perpendicular “leader” that acts as a partition to block fish from swimming past; a heart-shaped wall of nets that forces animals to swim in the direction of the pound, and a “pound net” that serves as the actual entrapment basin where fishers can collect and sort their catch (Figure 23).

In most cases, the tops of the nets poke out of the surface of the water, making sure that fish and other animals do not escape. As sea turtles swim parallel to shore, their path is blocked by the fence-like leader, where their fins or heads can be entangled, causing serious injury or death from drowning. Recent studies have shown that smaller mesh size and increasing net stiffness can lower sea turtle injuries and entanglement in pound nets. Turtles captured in the “pound” will survive and can be released easily.

Figure 23. Stationary pound net



Incidental catch of sea turtles is known to occur in set-nets and pound nets near nesting beaches in many countries. Bag nets that lack openings at the sea surface are particularly problematic because caught sea turtles cannot reach the surface to breathe and may drown before the gear is retrieved. Research that was conducted in Japan and which modified bag nets to include an escape gate similar to the TEDs used in trawl fisheries was shown to be successful. Because there are so many kinds of set-nets being used worldwide, studies that develop escape devices for each type of set-net are necessary.

Assessment and monitoring of sea turtle interactions and mortality in other marine capture fisheries is recommended. In particular, assessment of set-net fisheries other than gillnet fisheries is required. Research and development of measures that may help fishers to avoid encounters with sea turtles and, thereby, reduce sea turtle mortality is recommended. Implementation of effective turtle avoidance methods that are identified through research and development is encouraged.

Best practices for sea turtle handling and release

Fishers should implement best practices for the handling (including resuscitation) and release of sea turtles caught in fishing gear. They should also carry on board their vessels the equipment necessary for implementing handling and release practices.

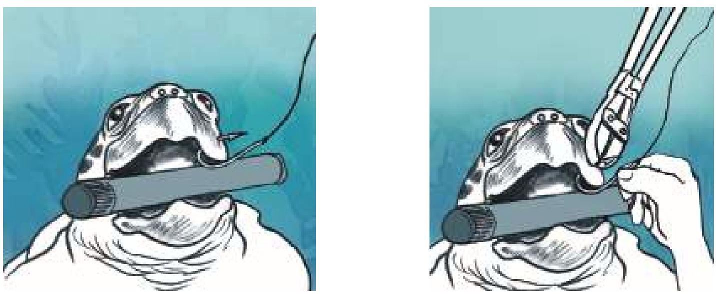
Much progress has been made in identifying best practices for handling and releasing turtles captured in pelagic longline fisheries. Various tools and techniques are required to remove fishing gear from captured sea turtles, reduce sea turtle injury and promote post-release survival.

Figure 24a–b shows how to retrieve and de-hook a turtle captured in longline gear, and Figure 25 shows how to resuscitate sea turtles caught in fishing operations. Figure 26 shows the equipment that can help fishers to employ best practices when handling and releasing hooked turtles and, thereby, minimize injuries to turtles. It is mandatory for this equipment to be carried onboard United States Atlantic pelagic longline vessels.

Figure 24. Best practices for (a) retrieving and (b) de-hooking turtles captured in pelagic longlines. (After Beverly, Chapman and Sokimi, 2003).

a) Retrieving a sea turtle

Assess the turtle's size, then release it or bring in on board. If the turtle is too large to bring on board, bring it as close to the boat as possible without putting too much strain on the line, then cut the line as close to the turtle as practical. If the turtle is small, use a dip net to lift the animal on board. DO NOT use a gaff and DO NOT pull on the line or grasp the eye sockets to bring the animal on board.



b) De-hooking a sea turtle

Place a piece of wood in the turtle's mouth so it cannot bite, then cut the hook or line.
If the hook's barb is visible, use bolt cutters to cut the hook in half, and remove the two parts separately.
If the hook is not visible, remove as much line as possible without pulling too hard on the line, and cut it as close to the turtle as practical.

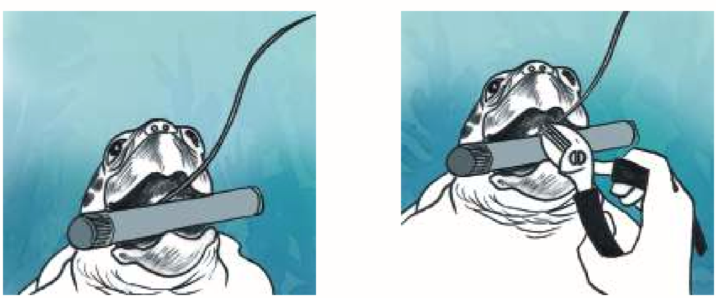


Figure 25. Turtle recovery procedures

Sea turtles caught in trawl nets, hooked in longlines or entangled in other gear may be stressed. Most are conscious and able to swim away after removal from the net, but some may be tired or appear lifeless. Turtles that appear lifeless are not necessarily dead. They may be comatose. Turtles returned to the water before they recover from a coma will drown. A turtle may recover on board your boat once its lungs have drained of water. This could take up to 24 hours. By following these steps you can help to prevent unnecessary turtle deaths (after Eayrs, 2007):

Land the turtle on your boat. Watch it for activity (breathing or movement).

If active

If not active

If active

i.e. moving strongly and breathing regularly...

Keep the turtle on board:
(a) raise the rear flippers about 20 cm off the deck to drain its lungs;
(b) keep it shaded and damp; and
(c) allow to recover for up to 24 hours.

If not active

Gently return the turtle to the water with:
(a) the engine in neutral when possible;
(b) nets not trawling; and
(c) without dropping the turtle on the deck.

The list of United States Government-approved equipment for turtle handling and release can be found at www.nmfs.noaa.gov/sfa/hms. The equipment required for Atlantic longline vessels by the Government of the United States of America includes the following (also shown in Figure 26):

[a] long-handled line cutter,

[b] long-handled de-hooker for ingested hooks,

[c] long-handled de-hooker for external hooks,

[c] long-handled device to pull an inverted V,

[d] dip net,

[e] standard automobile tyre,

[f] short-handled de-hooker for ingested hooks,

[g] short-handled de-hooker for external hooks,

[h] long-nose, needle-nose pliers,

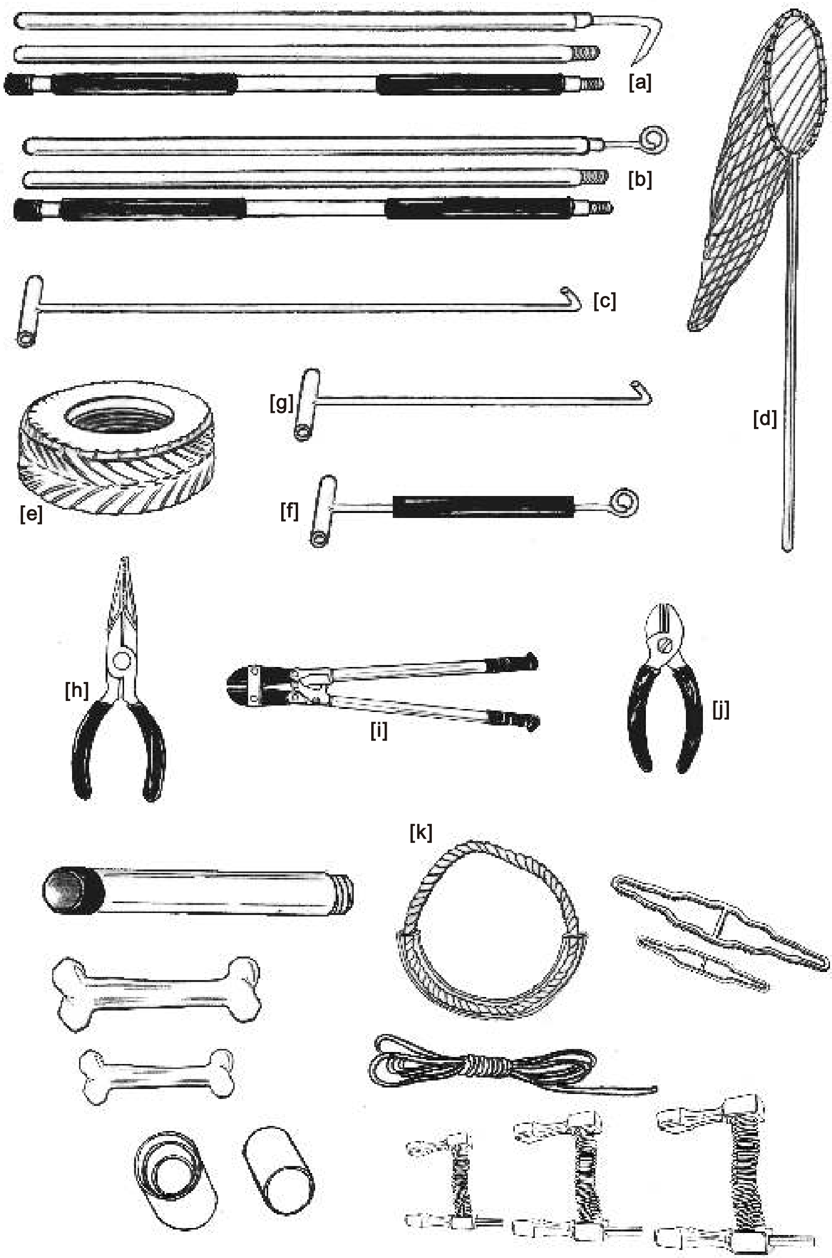
[i] bolt cutter,

[j] monofilament line cutter, and

[k] different types of mouth openers and mouth gags (including either a block of wood or metal tube, a set of three canine mouth gags, a set of two sturdy dog chew bones, a set of two rope loops covered with hose, a hank of rope, a set of four PVC splice couplings, or a large avian oral speculum).

The United States of America turtle handling and release protocol gives detailed instructions for using all of the above tools under various conditions.

Figure 26. Equipment used to handle and release sea turtles. The United States National Marine Fisheries Service requires this equipment to be carried on board United States Atlantic longline vessels (after U.S. National Marine Fisheries Service, 2004).



The United States Government protocol for handling and releasing sea turtles caught in pelagic longline gear protocols (www.sefsc.noaa.gov/seaturtletechmemos.jsp) is divided into three parts:

(i) Part 1: Vessel's responsibilities upon sighting a sea turtle;
(ii) Part 2: Sea turtles not boated; and
(iii) Part 3: Sea turtles boated.

The following is a summary of the United States turtle handling and release protocol.

Part 1: Vessel's responsibilities upon sighting a sea turtle

- scan the line far ahead;
- avoid moving ahead of the mainline;
- upon sighting a turtle, slow vessel and line drum speed;
- if slow speed is not possible, stop the vessel;
- take engine out of gear;
- pull branch line slowly;
- do not use sharp objects to retrieve or control turtle;
- assess turtle's condition and size and whether it is hooked or entangled;
- there are three possible interactions: entangled but not hooked, hooked but not entangled, and hooked and entangled;
- if hooked, assess the location of the hook;
- vessel must be stopped for assessment and boating of turtle;
- turtles three feet (about 90 cm) in straight carapace length can be boated safely if sea conditions permit; larger turtles should be boated when conditions and equipment permit;
- if the turtle cannot be boated, follow Part 2 of the protocols;
- whenever possible, turtles should be boated and Part 3 of the protocols should be followed; and
- the vessel is responsible for the turtle's safety from the first sighting until release.

Part 2: Sea turtles not boated

- the turtle should be brought as close as possible, but it may need a short time to calm down;
- gear removal must be done quickly, however, careful removal to ensure no further injury is the top priority;

- a turtle control device or tether (a line on a pole that is looped over one flipper) can be used to help control the animal; it takes pressure off the branch line;
- long-handled line cutter is used to cut monofilament line from entangled turtles;
- monofilament cutter is used to cut line if the turtle is close to the boat;
- long-handled de-hooker for internal hooks is used to remove internal hooks from sea turtles that cannot be boated;
- long-handled de-hooker for external hooks is used to remove hooks from flippers; and
- long-handled device to pull an inverted V during entanglement is used to assist in cutting away line; a gaff or boat hook can be used for this.

Part 3: Sea turtles boated

- it is important that the turtle is never pulled out of the water by using the branch line;
- if the turtle is small enough, a dip net can be used to carefully boat the turtle;
- for larger turtles, a hoist can be used; the hoist is a large basket-like device that is lowered and raised by a hydraulic crane or boom;
- while onboard, the turtle must be kept moist and in the shade, maintaining its body temperature above 60º F (15.5º C) or similar to the water temperature at capture;
- it must be isolated and immobilized on a cushioned surface; the hoist will do for larger turtles and an automobile tyre will do for smaller turtles;
- comatose turtles should be revived before being released; they can be kept on deck for 24 hours without a permit for resuscitation purposes;
- a turtle kept on deck for 24 hours without sign of life may be considered dead and should be returned to the water;
- if it is uncertain whether hook removal will cause more damage, then the hook should not be removed;
- all external hooks should be removed;
- hooks in the mouth should be removed;
- hooks that have been swallowed should not be removed when the insertion point is not visible;
- when a hook cannot be removed, the line should be cut as close as possible to the eye of the hook;
- if part of the hook is visible, it should be cut with bolt cutters and removed;

- if the turtle is hooked internally, its mouth needs to be opened: block the nostrils, tickle the throat or cover the nostrils and apply light pressure to the front corner of the eye with one hand and firm pressure to the throat with the other;
- otherwise, use rope loops covered with protective tubing or the avian mouth speculum to open the mouth. Then use mouth gags (block of wood, canine mouth gags, hank of rope, PVC pipe couplings) to keep it open;
- to obtain a better view after the mouth is open, insert a pair of needle-nosed pliers (in the closed position) into the upper oesophagus and then open the pliers;
- use pliers, bolt cutters or short-handled de-hooker to remove internal hooks;
- use bolt cutters and pliers, or a short-handled de-hooker, to remove external hooks;
- once gear is removed and the turtle recovered, boated turtles should be released in water of similar temperature as at capture, preferably in a non-fishing area;
- release the turtle by lowering it over the aft portion of the vessel, close to the surface, when gear is not in use and the engine is in neutral; and
- the turtle's swimming behaviour and diving ability should be monitored after release and recorded in the daily logbook.

A high proportion of turtles caught on shallow-set longlines can survive the gear soak and are alive when brought to the vessel during gear hauling. Although there is no empirical evidence to show that with better handling and release practices captured and released turtles have a higher chance of surviving, efforts to minimize injury to turtles might increase the turtle's ability to survive the interaction with longline gear.

Further readings on best practices for sea turtle handling and release

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Sea turtle bycatch hotspot avoidance

Fleet communication programmes and area and seasonal closures are management tools that can help a marine capture fishery to avoid turtle bycatch hotspots. These strategies may complement other strategies that aim to reduce sea turtle bycatch.

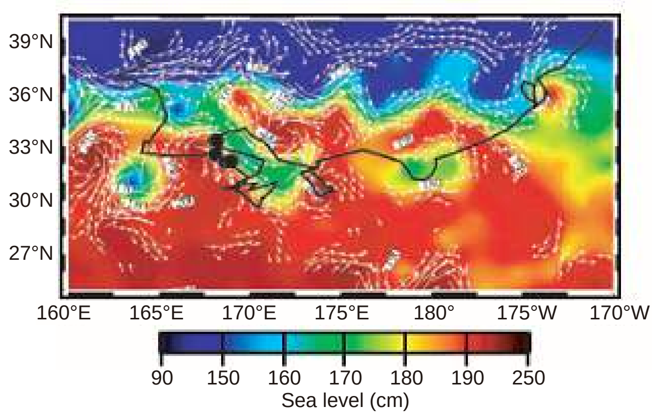
Time–area closures

There are well known areas and periods where overlaps of turtle habitat and fishing activity occur. Some sea turtles follow narrow migratory corridors from nesting beaches to foraging grounds, traversing several thousand kilometres. Other turtles are known to consistently migrate along specific routes to highly productive areas, or congregate at foraging grounds.

For example, sea turtles have been tracked to frontal zones and eddies that are high in chlorophyll and plankton productivity. However, these are oceanographic features that are also sought out by fishers and therefore result in interactions between fishing gear and turtles. Satellite tracking has demonstrated that the movement of loggerhead and olive ridley turtles in the central North Pacific is associated with temperature and chlorophyll fronts, eddies associated with sea surface height (SSH) anomalies and geostrophic currents. The two species were observed to occupy different areas (Figure 27).

Spatial and temporal restrictions on fishing, especially in areas where there is a high concentration of sea turtles, or during periods of turtle abundance, is

Figure 27. Geostrophic currents, sea surface height and loggerhead movements (black line) and positions (black dots). The loggerheads spent most of the time at about 33º N and 170º W, along the edge of a meander and eddy. Source: Polovina, J.J., Balazs, G.H., Howell, E.A., Parker, D.M., Seki, M.P. & Dutton, P.H. 2004. Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fish. Oceanogr.* 13 (1): 36–51.



encouraged. Such restrictions will contribute to reducing sea turtle interactions and mortality in marine capture fisheries. Area and seasonal closures enable marine capture fisheries to avoid peak areas and periods of sea turtle foraging, nesting and migration. Although closed areas can have substantial adverse economic effects on the fishing industry, they are a tool that fishery managers can use to complement other management measures. A closed area may also be a more desirable option than a closed fishery.[1]

Identifying with a high degree of certainty the location of migratory routes, the timing of migrations and other sea turtle hotspots could assist with the design of time or area closures for the fishing industry.

[1] For example, the Hawaiian longline fishery for swordfish was closed for over two years owing to problematic turtle interactions. It is now subject to strict management measures, including the prescribed use of wide circle hooks and fish bait, restricted annual effort, annual limits on turtle captures and 100 percent onboard observer coverage. Similar restrictions have been implemented in the western North Atlantic. An area of over 7.7 million km^2, including the productive Grand Banks, was partially closed to the United States pelagic longline fleet in 2000 and completely closed in 2001, owing to problematic turtle bycatch levels. The Grand Banks were re-opened to this fleet in the summer of 2004 after regulations were amended. Regulations now require the use of recently tested turtle bycatch avoidance methods.

Establishing MPAs that include turtle nesting colonies and adjacent waters can help to reduce interactions between sea turtles and commercial fisheries. However, managers need to consider carefully a wide range of variables when selecting a site for, and designing, an MPA. It is possible that unforeseen adverse effects may follow the introduction of an MPA. For example, placing restrictions on resource use in an MPA may displace effort to adjacent and potentially more sensitive areas where adverse effects from the displaced effort on turtles, other sensitive bycatch species groups or commercially important species can be substantial. This is especially problematic if an effective management regime does not exist for these other areas. This occurred after the northwest Atlantic longline fishery for swordfish was closed: fishing effort was displaced to the South Atlantic, where few or no controls were in place to manage turtle bycatch.

Another important consideration is that closing areas to fleets from countries that are party to a MPA convention or agreement, might encourage fleets from non-party states – with fewer or no controls for managing bycatch – to fish in the closed area. This might ultimately exacerbate the problem for which the MPA was originally established. A scenario like this may occur if the new MPA causes a reduction in the catch of target species by fleets of participating states and fleets from non-party states increase fishing effort to meet demand. In short, measures adopted by RFMOs and other international bodies are only binding for those countries that are party to the convention that established the RFMO. The measures will not control activities by non-party states. Furthermore, IUU fishing activities will also pose a challenge to the efficacy of high seas MPAs, especially if resources for surveillance and enforcement are not in place.

Establishing high seas MPAs to restrict fishing in sea turtle foraging areas and on migration routes may be problematic for other reasons. Such MPAs would require extensive and dynamic boundaries, defined in part by the location of large-scale oceanographic features and short-lived hydrographic features such as eddies and fronts. They would also require extensive buffer zones. It is anticipated that considerable time would be required to resolve legal complications around international treaties, to achieve international consensus and to acquire the requisite resources for enforcement.

Nonetheless, the establishment and management of a representative system of protected area networks on the high seas may contribute to the management of interactions between marine capture fisheries and highly migratory sensitive species groups, e.g. seabirds, sea turtles and cetaceans, as well as habitats or oceanographic features, e.g. pelagic drift algae, fronts and gyres.

An initial obstacle to overcome would be to create legally binding mechanisms for multilateral designation and management of high seas MPAs. Recent developments within the framework of the United Nations Convention on the Law of the Sea (UNCLOS) and associated conventions, as well as by several RFMOs, may make it possible to establish MPAs on the high seas in the near future. (Several RFMOs are updating their scope and legal mandate to include ecosystem-based management and biodiversity conservation under the auspices of the Fish Stocks Agreement.)

It is already possible to establish high seas MPAs for discrete areas by forging agreements between individual countries. However, a need remains for an international framework, with specific language, to identify the criteria for the establishment of a representative system of high seas MPA networks, as well as management and enforcement measures for the individual MPAs.

A spatially fixed closed area is not likely to protect highly migratory endangered species effectively. This is especially true for large pelagic ecosystems, which are characterized by highly dynamic oceanographic processes, both on a temporal and spatial scale. If high seas MPAs are to protect highly migratory species, they would require extensive and dynamic boundaries, as well as large buffer zones. Therefore, a second obstacle to overcome is the development of a scientific basis for the design of high seas MPAs to protect highly migratory species and habitats. For example, food web models have demonstrated that the establishment of MPAs may result in changes in the distribution of mobile marine organisms, including sea turtles. This is as a response to increased population sizes of predators and decreased population sizes of prey species within MPAs and would necessitate complex designs for high seas MPAs.

Marine protected areas can effectively reduce fisheries bycatch of sensitive highly migratory species only where the location and times of migration or aggregation are known. Fortunately, knowledge about the influence of topographic and oceanographic features on the distribution of sensitive species is improving.

The advantages and disadvantages of time and area closures		
Bycatch avoidance method	**Advantages**	**Disadvantages**
Time and area closures	- Fishing industry avoids high-risk areas and periods of peak sea turtle abundance - Sea turtle interactions and mortality are reduced - Contribute to ecosystem-based management approaches	- May result in substantial economic effect on fishing industry and fishers - Difficult and time-consuming to negotiate - High seas MPAs need to be very large, with flexible boundaries - Might displace fishing effort to areas with fewer controls - May have unforeseen adverse ecosystem impacts - Need to be well monitored and enforced

Fleet communication

Fleet communication programmes can encourage the reporting, in real time, of observations of bycatch hotspots so that these may be avoided by vessels in a fleet. Fleet communication may help vessels to avoid areas or time periods when turtles and other sensitive species, such as seabirds and cetaceans, aggregate. There is evidence to suggest that fleet communication programmes can substantially reduce fisheries bycatch and provide economic benefits that greatly outweigh operational costs.

Fleet communication may be appropriate in fisheries where: (i) there are strong economic incentives to reduce bycatch; (ii) interactions with bycatch species are rare events; (iii) adequate onboard observer coverage exists; and (iv) there are large fleets where vessels are represented by a fishery association. For example, over a period of seven years, when some vessels were not participating in the Alaskan demersal longline fleet communication programme, the average halibut bycatch rates of non-participating vessels were 10–30 percent higher than participating vessels. Another example is provided by the United States North Atlantic longline fishery for swordfish, which conducted a research experiment between 2001 and 2003, a period when the industry was implementing a fleet communication programme. While using traditional J hooks, turtle bycatch rates in the fishery were 50 percent lower than historic turtle bycatch rates, a finding that suggests the implementation of the fleet communication programme did reduce bycatch rates.

There is also evidence that sea turtle captures often occur in clusters, a phenomenon that suggests the implementation of real-time turtle bycatch hotspot avoidance can be beneficial. A study of the Hawaiian longline fishery for swordfish demonstrated that one-quarter of caught turtles were in clusters – consecutive sets with a caught turtle and greater than one turtle per set. There is less than a 0.4 percent ($P < 0.005$) probability that $\geq$ 24 percent of the 231 sets with caught turtles would be consecutive if the events were independent and not serially correlated. Furthermore, of 264 caught turtles, 23 percent (62 turtles) were caught in a set with two or more turtle captures. These results suggest that sea turtles aggregate at foraging grounds or other areas, where there may be a higher probability of catching a turtle in consecutive sets. Therefore, after a turtle is caught, additional sea turtle interactions may be avoided by moving a fishing vessel away from the area or moving to an area where different oceanographic conditions prevail (e.g. where the sea surface temperature is different) before making another set. Avoiding fishing in the vicinity where the turtle was caught for a certain time period and employing other methods to avoid real-time turtle bycatch hotspots – such as fleet communication programmes – could contribute to reducing sea turtle interactions.

Input controls – fishing effort and capacity limits

Limits on capacity (number of vessels of a specified size) and effort (number of sets or hooks or number of days fished) can contribute to reducing sea turtle interactions and mortality. Input controls are encouraged, especially if these are required for the conservation and management of target species or groups of target species. However, input controls may need to be instituted regionally. Introducing input restrictions for only one fleet may result in an increase in effort or capacity by other fleets with fewer or no controls for managing turtle bycatch.

Output controls sea turtle caps, target species caps

Output (catch) controls are usually aimed at target species, but they can also apply to bycatch species. For example, the United States National Marine Fisheries Service has established annual catch limits (caps) for loggerhead and leatherback captures for some domestic longline fisheries. As with input controls and time–area restrictions, however, output controls may need to be instituted regionally. Introducing output restrictions for a single fleet may result in increased catches by other fleets that may have fewer or no controls for managing turtle bycatch.

Bycatch fees and other methods of compensation

Where possible, conservation initiatives that offset sea turtle mortality caused by fishing, should be considered. For example, individual vessels in a fleet or a fisheries association could compensate for catching sea turtles by contributing to a public or private organization that conducts sea turtle conservation projects. Fees could be collected from a range of organizations whose activities have an impact on the mortality of sea turtles and thereby fund larger projects that may be more beneficial than projects that are funded from one source only. Fishers and fishing fleets may prefer fee-based compensation over other management options – such as temporal and spatial closures or annual turtle catch limits – because it may allow them to meet their obligations more quickly and cost-effectively. It may also be easier for regulators to manage, monitor and maintain a single sea turtle compensation programme.

Fisheries management authorities could create a fee and exemption structure for the bycatch of sensitive species in marine capture fisheries. Such schemes could be applied to individual vessels or to an entire fleet in a way that is similar to a "polluter pays" system. For example, governments could reduce or withhold subsidies to vessels or an entire fleet, charge a higher permit or licence fee, or require payment of a higher tax rate if bycatch rates, TAC of bycatch species or other thresholds are exceeded. The fee structure would serve as an economic target species. However, input controls may need to be instituted regionally. Introducing input restrictions for only one fleet may result in an increase in effort or capacity by other fleets with fewer or no controls for managing turtle bycatch.

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Avoidance and reduction of derelict fishing gear and other marine debris

Derelict fishing gear, a component of marine debris, poses substantial ecological and economic problems globally. The problem of derelict fishing gear threatens endangered species, including sea turtles, and coastal ecosystems such as coral reefs. It also results in “ghost fishing” as the lost or discarded gear continually catches and kills fish and other marine life. Derelict fishing gear also has the potential to introduce invasive alien species. The debris poses an obstruction to navigation, clogging vessel intake valves and snaring propellers, stranding vessels, placing vessels and crew in danger and it can foul fishing gear, which, in some cases, requires costly repairs. The development and implementation of fishing gear retention and recycling schemes is encouraged in order to minimize the disposal of fishing gear and other marine debris at sea.

Retrieval of derelict fishing gear and other debris

The development and implementation of methods to facilitate the retrieval of derelict fishing gear and other marine debris is encouraged, in part to reduce adverse effects of marine debris on sea turtles. For example, the Republic of Korea has an incentive programme for fishers to retrieve marine debris, and the fishery management authority for the Hawaiian longline fisheries has created a seaport reception facility to receive and recycle derelict fishing gear that is voluntarily collected on fishing grounds in the North Pacific.

The advantages and disadvantages of fleet controls		
Bycatch avoidance method	**Advantages**	**Disadvantages**
Fleet communication programmes	- Help fishing vessels to avoid areas and time periods of peak sea turtle abundance - Encourage self-regulation and industry buy-in to sea turtle conservation - Help to avoid "cluster" catching of sea turtles	- Some coordination and management costs involved
Input and output controls (effort control)	- Limit fishing effort, which helps to limit sea turtle interaction levels	- May not be respected by fleets that are not part of the effort limitation agreement - May need to be implemented on a regional basis
Output controls (sea turtle or target species catch limits)	- Can limit industry to a sea turtle bycatch level - Can limit industry to catch levels for target species that may result in reduced annual/seasonal effort and might reduce turtle catch levels - Raise awareness of the issue of bycatch and encourage self-regulation	- May have economic impact on fishing industry if a limit is reached and fishing is halted or if a limit is exceeded, resulting in punitive measures
Bycatch fees	- Create an incentive for the fishing industry to take measures to avoid and minimize turtle interactions - Can contribute towards mitigating other threats to sea turtle populations	- Probably requires 100 percent observer coverage

Summarized listing of main mitigation measures	
1. Management measures	**Applicable to fisheries/gear**
• area closures • seasonal closures • effort limitations • access limitations • TAC/quotas on non-target species • avoiding bycatch hotspots • bycatch fees and other methods of compensation	All fisheries
2. Technical measures	Set gillnets, drifting gillnets
• setting nets perpendicular to the shore to reduce interactions with nesting females • using deterrents, including sonic “pingers”, shark silhouettes, lights or chemical repellents • deeper setting, avoiding the upper water column where turtles are most abundant • renunciation of “tie-down” ropes • use of lower nets	
• using wide circle hooks • using fish rather than squid for bait • setting hooks deeper than turtle abundant depths (40–100 m). • single-hooking fish bait rather than threading the hook through the bait multiple times • reducing gear soak time and retrieving gear during daytime	Pelagic longlines, bottom-set longlines
• use of TEDs	Trawl fisheries
• avoid the encirclement of sea turtles	Purse seine
• if encircled, hooked or entangled, take all possible measures to release turtles safely	All fisheries

Consideration of effects on other sensitive species groups

When designing or planning the implementation of methods to reduce interactions between sea turtles and marine capture fisheries, the effects of these methods on other sensitive bycatch species groups need to be considered. It is important to identify conflicts and mutual benefits that bycatch reduction strategies may have on other species groups. Use of wider circle hooks and fish bait is currently the most common approach for reducing turtle interaction and mortality in pelagic longline fisheries. However, the effect of different hook and bait combinations on other sensitive species groups warrants attention. For example, analysis of observer data from the United States North Atlantic longline fishery for swordfish, showed a six times lower seabird CPUE with circle hooks compared with J hooks. Furthermore, switching from squid to fish for bait has consistently been found to cause large and significant reductions in shark CPUE. It is likely that this change in bait will also result in reduced seabird CPUE, although empirical evidence for this single factor effect has yet to be identified. There are inconsistent observations of the effect on shark CPUE of switching from tuna and J hooks to circle hooks; in a limited number of studies, the change in hook caused either no change or a significant but small increase in shark CPUE. Increasing the setting depth and timing of fishing operations to avoid sea turtles can result in substantial changes in CPUE of target, incidental and discard species, depending on the location of fishing grounds.

Research, monitoring and information exchange

Observer, logbook and landings data collection

The collection of information and data are recommended, particularly:

- (i) The collection of information on sea turtle interactions in all fisheries, directly or through relevant RFBs, regional sea turtle arrangements or other mechanisms.
- (ii) Development of observer programmes in fisheries that may have impacts on sea turtles, where such programmes are economically and practically feasible. In some cases, financial and technical support might be required.
- (iii) Joint research with other states and/or FAO and relevant RFBs.
- (iv) Research on the survival of released sea turtles.
- (v) Research to identify areas and time periods characterized by high sea turtle interactions.
- (vi) Research on the socio-economic impacts of sea turtle conservation on fishers and fishing industries and ways to improve communication.
- (vii) Use of fishing communities' traditional knowledge about sea turtle conservation.

Estimates of turtle mortality are very important for improving our understanding of the effect of marine capture fisheries on sea turtle populations. Observer data can also be used to assess the efficacy of measures aimed at reducing sea turtle interactions. Onboard observers require training to ensure accurate identification of turtle species, handling and release protocols, as well as protocols for data recording, such as employment of standardized descriptions of fishing gear and methods.

Observer coverage and data recording protocols are required to: (i) improve our understanding of turtle–fishery interactions, including the disparate effects of specific fishing gear and methods; (ii) assess the size of the problem of sea turtle interactions; (iii) determine when and where interactions occur; (iv) identify both spatial and temporal bycatch hotspots; (v) observe interaction rates and thereby provide a basis for fleet-wide extrapolations; and (vi) verify logbook data.

The objective of an observer programme will determine the appropriate onboard observer coverage rate. For example, an observer programme designed to ensure that annual sea turtle interaction caps are not exceeded would require 100 percent coverage. However, the coverage required to provide an extrapolation of annual turtle interaction levels across a fishing fleet might be in the order of 20 percent.

Logbook data provide information on the quantity, timing and location of fishing effort, as well as information on catches (including bycatch and discard species). However, logbook-derived information about sea turtle interactions is known to be unreliable. For example, in the Hawaiian longline fishery, there were about 11 times more turtles being taken than were recorded in logbooks.

Landing receipts and direct sampling of landings at fishing ports also provide fundamental information on retained catch and value.

Sea turtle catch rates are typically reported as the number of sea turtles of each species caught per unit of fishing effort, i.e. number of sea turtles per 100 or per 1 000 hooks set in longline fisheries, per set in trawl and purse seine fisheries, or per length or area of net in gillnet fisheries. Information on sea turtle abundance around fishing vessels is not available and this makes it impossible to determine the effect of turtle abundance on capture rates. As a result, it has not been possible to normalize capture rates for turtle abundance (e.g. x turtles per 1 000 hooks per sea turtle), as has been accomplished for seabirds, consistent with the accepted understanding of animal abundance and the capture process. As a result, observation of high or low turtle catch rate by a vessel may not indicate the vessel was or was not effectively employing best turtle avoidance practices, but instead may primarily be a factor of the abundance of turtles around the vessel's gear.

Alternative sources of data on sea turtle interactions with fishing gear		
Bycatch avoidance method	**Advantages**	**Disadvantages**
Observer data	- Trained observers can provide a wealth of information about sea turtle interactions, provide estimates of sea turtle mortality and assess the efficacy and commercial viability of fishing gear designs and fishing methods	- Observer programmes are expensive - Observer coverage rates may need to be high for certain parameters - Observers need to be well trained
Logbook data	- Fishers' logbooks can provide valuable information about catches, including bycatch and discards - Fishers can be made to feel part of turtle conservation efforts if their logbook data is put to good use	- None
Monitoring of landings	- Provides information on retained catch and value	- None

Research and commercial demonstrations

Research and commercial demonstrations are needed to:

(i) Assess the number of sea turtle interactions for fisheries where observer coverage has not already provided this information. For example, some nations do not operate fisheries observer programmes or have low coverage rates.

(ii) Better understand the behaviour of sea turtles in relation to the different characteristics of fishing gear and fishing methods.

(iii) Improve estimates of mortality from different types of turtle interactions.

(iv) Assess the efficacy and commercial viability of alternative fishing gear designs and fishing methods. For example, after fleet-wide adoption of a turtle avoidance strategy, it is important to determine the economic effects of implementing the measures, and to assess efficacy to determine if there is consistency with observed results from trials.

(v) Develop improved equipment and methods for handling and releasing turtles so as to optimize the likelihood of turtles surviving interactions with marine capture fisheries.

In addition to assessing the efficacy of various strategies for reducing turtle interactions in marine capture fisheries, it is also imperative to determine the commercial viability of turtle avoidance methods. Commercial viability refers to: (i) how practical a method is for the fishing crew to employ, and (ii) the economic effect of implementing the method. For example, a commercial demonstration in a longline fishery may look at how switching from a non-circle hook to a circle hook affects the catch rate of target species. It may also determine whether the new hook has any practical impacts, such as changing the crew's ability to place baits on the hook or their ability to work safely with the new hook.

Testing takes time

Assessments of turtle bycatch avoidance methods need to be conducted over several seasons to determine whether they are consistently effective and commercially viable under varying conditions and over time. Such trials also help the fishing industry to become familiar with modified fishing gear and alternative fishing methods and thereby develop support for their fleet-wide use.

Research on turtle bycatch avoidance should be designed to assess effects on other sensitive bycatch species. It is important to identify conflicts as well as mutual benefits of bycatch reduction strategies between species groups.

The primary goal of identifying methods for reducing sea turtle capture in marine capture fisheries is to help to reverse downward trends in sea turtle populations and to prevent the extinction of turtle species. To achieve this goal, it is necessary to consider a method's effectiveness at reducing turtle capture and injury as well as its commercial viability.

Research needs to be conducted in the following areas:

- Determining the degree of sea turtle interactions in specific fisheries.
- Better understanding turtle behaviour and interactions with fishing gear.
- Improved post-release mortality estimates.
- Testing gear modifications to make them effective and viable.
- Standardizing hook nomenclature.

Information exchange

Conferences and workshops provide an opportunity for the exchange of information and lessons learned from managing interactions between sea turtles and marine capture fisheries. Over the past decade, there have been numerous workshops and meetings that have brought researchers, fisheries managers and fishers together to work on bycatch solutions.

Incentives for industry participation

Incentives are a useful tool for biodiversity conservation and hold promise for minimizing bycatch of sensitive species in marine capture fisheries. Incentives and inducements that persuade stakeholders to conserve biological diversity and use its components sustainably include:

- ecolabelling programmes;
- bycatch fee and exemption structures;
- formal legal and regulatory constraints;
- industry self-policing;
- programmes that make technology available to minimize adverse environmental impacts and increase economic efficiency.

Commercial fishers have a large repository of knowledge related to sea turtle bycatch. This knowledge can be tapped by introducing incentives that help to develop effective and practical solutions. For example, fishers and fishing associations might be encouraged to participate actively in addressing turtle bycatch problems before restrictions, embargos and possible closures are imposed on them. Some of the ways in which fishers may become involved are by taking part in research and commercial demonstrations, implementing best practices and supporting the adoption of regulations based on best available science.

Provide or exchange equipment

Programmes that provide equipment to fishers free of charge, or at a reduced cost, can promote the fishery-wide use of an avoidance method. For example, the United States Fish and Wildlife Service funded a programme that gave away bird-scaring lines to Alaskan longliners and shared the costs of installing davits (the devices that hold the tori lines) on larger longline vessels. In Ecuador, a hook exchange programme, whereby circle hooks of various sizes were voluntarily exchanged for J hooks on 115 participating vessels, proved successful. Tools and instructions for releasing turtles were provided to fishers and an observer programme was conducted to monitor the effects of the hook exchange programme.

Industry self-policing

A fishing industry can introduce a programme whereby information about individual vessel bycatch levels, compliance with regulations, and other relevant information is made available to the entire industry. This method is especially effective when regulations contain industry-wide penalties, e.g. if penalties such as a reduced fishing season, the introduction of closed areas, or the complete closure of a fishery are introduced when bycatch rates are exceeded by the fleet. This kind of self-policing programme uses pressure from within the industry to criticize bad actors and publicly acknowledge good actors. For example, the North Pacific Longline Association initiated a seabird report card system among its members in 2000. Members agreed to share seabird bycatch information and employed a private company to provide performance summaries linking seabird takes to individual vessels. The company contacted vessels with high seabird catch rates so that they could act immediately to rectify the vessel's high bycatch rate.

Economic incentives: ecolabelling and sustainable seafood programmes

Consumer demand can alter industry behaviour. In 2005, the COFI adopted Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries. The Guidelines provide assistance to governments and organizations that already maintain, or are considering establishing, labelling schemes for certifying and promoting fish and fishery products from well-managed marine capture fisheries.

A fishing industry may pursue accreditation from an ecolabelling certification programme to demonstrate that it is well managed and employs international best environmental practices. Certification may increase demand for, and the value of, the industry's products. When it is well managed, ecolabelling can serve as an effective marketing tool for a fishing industry. Certification allows a company to differentiate its products from others and realize market-related benefits.

Several major seafood retailers have established sustainable seafood programmes that guide their seafood sourcing. With sustainable seafood programmes, a retailer conducts an independent audit of marine capture and aquaculture industries to determine which fisheries are a source of sustainable seafood products. Some retailers consider whether or not a fishery has obtained certification through the Marine Stewardship Council (MSC), an international organization that has established a certification programme for seafood and uses an easily recognized label for seafood products derived from accredited fisheries. The MSC's principles and criteria for assessing fisheries aim to avoid overfishing, prevent adverse ecosystem impacts and ensure a responsible management framework is in place that leads to sustainable fishing practices. Seafood retailers may also refer to seafood score cards that recommend that consumers purchase only species that are assessed as being from sustainable fisheries.

Legal and policy frameworks

FAO has highlighted the importance of achieving consistency in management and conservation policy at the national and regional levels. Maintaining consistency and seeking the harmonization of sea turtle management and conservation-related legislation at the national, subregional and regional levels is also prioritized.

There is a wide array of binding and non-binding global, regional and national instruments to guide nations and industries that wish to address the problem of sea turtle interactions with marine capture fisheries.

Global instruments

Global instruments and agreements provide the legal framework for governments to advance the sustainable conservation and management of living marine resources.

- The United Nations Convention on the Law of the Sea (UNCLOS) is considered to be a "Constitution for the Oceans". It was adopted in 1982 and entered into force in 1994. Although some countries are not party to the UNCLOS, many non-parties consider it to be customary international law. In addition to establishing areas of jurisdiction in the oceans (exclusive economic zones or EEZs, for example), the UNCLOS also establishes general rules for fishery conservation and management.
- The 1993 FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the Compliance Agreement) sets flag state responsibilities for high seas areas, including requirements for the authorization of specific fishing activities and control of high seas vessels. The Compliance Agreement calls on flag states to prevent their vessels from undermining agreed fishery conservation and management measures.
- The 1995 United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement or UNFSA) applies to the management of fisheries for straddling stocks and highly migratory stocks in EEZs and on the high seas. The UNFSA strengthens the UNCLOS rules on

fisheries. It incorporates the precautionary approach and the concepts of compatibility of measures, and provides additional responsibilities for states, such as the enforcement of conservation and management measures. This agreement also notes the importance of preserving biodiversity, of maintaining the integrity of marine ecosystems and of minimizing the risk of long-term irreversible effects.

- The 1995 FAO Code of Conduct for Responsible Fisheries (CCRF) is a voluntary instrument. It is applied globally and is based on international law, including the UNCLOS. The CCRF provides principles and standards that, among other things, call for sustainable use of aquatic ecosystems and for fisheries to be conducted with due regard for the environment. The CCRF specifically addresses biodiversity issues and conservation of endangered species, calling for the bycatch of non-target species and the impacts of fisheries on biodiversity to be minimized.
- International plans of action (IPOA) elaborate on specific aspects of the CCRF. For example, the International Plan of Action to Deter, Prevent and Eliminate IUU Fishing was adopted in 2001. It was designed as a “toolkit” that states can draw on to stop IUU activity. Some of the measures included in the IPOA are coastal, port and flag state measures.

In addition to the fisheries-oriented agreements cited above, there are several other global agreements that also provide a context for action to conserve sea turtles. Good examples are the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on Biological Diversity (CBD), and the Convention on Migratory Species (CMS).

Regional level

There are currently no legally-binding measures in place by any IGO, including RFMOs, to address sea turtle-fishery interactions. The major RFMOs with management responsibilities for fisheries that interact with sea turtles include the General Fisheries Commission for the Mediterranean (GFCM), the Indian Ocean Tuna Commission (IOTC), the Inter-American Tropical Tuna Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Western and Central Pacific Fisheries Commission (WCPFC). Another RFMO, which manages tuna and tuna-like species, the Commission for the Conservation of Southern Bluefin Tuna

(CCSBT), has a convention area in higher latitudes where, it is understood, sea turtle interactions are not problematic.

Some of these RFBs have begun to examine sea turtle bycatch, or have adopted voluntary measures to address bycatch as part of their overall fisheries management schemes. The Northwest Atlantic Fisheries Organization (NAFO) and the South East Atlantic Fisheries Organization (SEAFO) are additional RFBs whose mandates do not include fisheries for tunas and billfish.

Other RFBs serve as advisory mechanisms for conducting cooperative scientific research and provide advice to members. These types of organizations include the Western Central Atlantic Fishery Commission (WECAFC), the Fishery Committee for the Eastern Central Atlantic (CECAF) and the Organización Latinoamericana de Desarrollo Pesquero (OLDEPESCA, the Latin American Organization for Fisheries Development).

Currently, there are three multilateral agreements with the primary responsibility of regional sea turtle conservation. These agreements – the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA MoU) and the Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (West Africa MoU) – address the range of sea turtle conservation and protection issues and incorporate provisions to address interactions with fisheries. Although these agreements do not have fisheries management authority, they do carry obligations for member states to take bycatch-related actions for areas under their jurisdiction.

IUU fishing may pose a threat to sea turtles because IUU vessels are unlikely to employ measures to reduce sea turtle interactions and mortality. While it is beyond the scope of this report to review IGO measures to address IUU fishing, several RFBs have taken steps to effectively reduce IUU fishing, including instituting requirements for vessel monitoring systems (VMS), managing lists of authorized (approved) and illegal vessels, port and at-sea inspection programmes, and trade documentation programmes.

Voluntary resolutions and recommendations adopted by RFMOs to reduce adverse effects on turtles from fishery interactions have been consistent:

- **IOTC**: In 2005, the IOTC adopted the non-legally-binding Recommendation 05/08 on sea turtles, which recommends: (i) implementation of the FAO guidelines to reduce sea turtle mortality in fishing operations by vessels operating in the IOTC convention area; and (ii) adoption of handling and release best practices, including specific turtle avoidance measures for purse seine and longline gear. The recommendation further encourages contracting parties and cooperating non-contracting parties to voluntarily collect and provide the IOTC Scientific Committee with information on sea turtle interactions and other impacts on sea turtles in the IOTC area, such as threats to nesting sites and from marine debris.
- **ICCAT**: In 2003, the ICCAT adopted Resolution 03-11, Resolution by ICCAT on sea turtles. The resolution encourages: (i) the collection and voluntary provision of data on sea turtle interactions in ICCAT fisheries and other threats to sea turtles in the convention area, including threats to nesting sites and from marine debris; (ii) the live release of incidentally caught sea turtles; and (iii) the sharing of information on technical measures to reduce incidental turtle bycatch levels and implement handling and release practices. The resolution also calls for the development of data collection and reporting methods for the incidental bycatch of sea turtles in fisheries for tuna and tuna-like species. In 2005, the ICCAT adopted a resolution on circle hooks that encourages research into the use of circle hooks in pelagic longline fisheries, as well as recreational and artisanal fisheries. The resolution also encourages information exchange to improve the handling and release of incidentally caught sea turtles and thereby improve post-release survival prospects.
- **IATTC**: In 2004, the IATTC adopted a three-year programme to mitigate the impact of tuna fishing on sea turtles. The three-year programme calls for: (i) the collection and analysis of information on sea turtle fishery interactions in the eastern Pacific Ocean; (ii) a review of the efficacy of sea turtle avoidance methods and their impact on catch rates of target species; (iii) education of the fishing industry; and (iv) establishment of a voluntary fund to augment the capacity of coastal developing countries to improve conservation of sea turtles. Programme activities have included (i) the exchange of circle hooks for J, tuna or narrower circle hooks; (ii) distribution of

de-hookers; (iii) placement of onboard observers to monitor hook trials; and (iv) training in data collection and database management for participants in the hook trials. The programme has been active in Ecuador, Peru, Colombia, Panama, Costa Rica and El Salvador. Trials of circle hooks have also been reported by Japan, Republic of Korea, United States of America, Spain and Taiwan Province of China. The IATTC consolidated resolution on bycatch also identifies voluntary measures to address bycatch of sea turtles.

- **SEAFO**: In 2006, the SEAFO adopted a non-legally-binding resolution to reduce sea turtle mortality in fishing operations. The resolution calls on members to (i) implement the FAO guidelines; and (ii) collect and provide the SEAFO Secretariat with information on sea turtle interactions in SEAFO-managed fisheries.
- **WCPFC**: A resolution to mitigate the impact of fishing for highly migratory fish species on sea turtles is included in the WCPFC convention. It came into effect in 2006 and calls for: (i) implementation of the FAO guidelines to reduce sea turtle mortality in fishing operations; (ii) voluntary provision of data on turtle interactions in WCPFC-managed fisheries; and (iii) employment of specific turtle avoidance measures and research on avoidance methods, for purse seine and longline gear. The resolution also calls for: the review of observer programme data collection protocols to ensure observers are collecting appropriate information on sea turtle interactions; and the centralization of observer data on bycatch to obtain better estimates of total sea turtle catch and mortality in relevant fisheries. From 2006, annual reports to the WCPFC must include information on steps taken to implement the resolution. Additional work is required to ensure that members and cooperating parties comply with this and other provisions of the WCPFC.
- **NAFO**: is an intergovernmental fisheries management and scientific body. The NAFO manages the fishery resources of the northwest Atlantic Ocean, excluding salmon, tunas, marlins, whales and sedentary species. In 2006, the NAFO adopted a resolution to reduce sea turtle mortality in NAFO fishing operations. The resolution: (i) recognizes the important role that RFMOs can play in implementing the FAO guidelines; (ii) recognizes that the NAFO convention area includes critical foraging habitats for leatherback turtles; and (iii) invites contracting parties to provide information on data collection and observer training efforts relating to sea turtle interactions in NAFO-managed fisheries.

The mandate of RFBs is usually to cooperate in maintaining populations of exploited species at sustainable levels. As ecosystem considerations are a relatively new concern, there are few instances where the mandates of RFBs make explicit reference[2] to the conservation of non-target species occurring in the same ecosystem.

Member states could consider revising the mandates of RFBs that deal with the management and conservation of tuna and tuna-like species. The RFBs could be encouraged to adopt measures consistent with the wider scope of fisheries management, as outlined in the CCRF and the Guidelines on Ecosystem Approaches to Fisheries Management. The scope of these bodies should be broadened to include the sustainability of vulnerable bycatch species.

National level

There have been significant changes in national legislation governing sea turtles. In the mid-1960s, concerns were primarily related to the exploitation of sea turtles and were dealt with under hunting and fishing laws. Currently, however, national efforts are directed at promoting integrated conservation and management. These changes have been driven by developments in international law and by initiatives in a number of countries.

There is considerable variation in national legislation and, consequently, different practices in different countries. Variation is evident in conservation and management measures, as well as in the variety of laws and regulations governing hunting, environment, fishing, habitat, endangered species, biodiversity and trade, all of which may be used to regulate human activities that affect sea turtles. In some countries, conservation and management approaches are fragmentary or patchy, but in others they are comprehensive and holistic. At the national level, countries should work to integrate legislation that deals with turtles and thereby achieve the desired environmental objectives for sea turtle conservation and management.

[2] E.g. the Antigua Convention in the Eastern Pacific Ocean.

Harmonization of laws and policies

The number and scope of national laws and regulations reflect a broad concern for the plight of endangered species and an awareness of the need to exploit living resources sustainably. However, a large variety of laws and lack of harmony may create complex situations at the national and international levels. Therefore, there is a need for the harmonization of legislation governing sea turtle conservation. Furthermore, owing to the migratory and transboundary characteristics of sea turtles' life history, conservation and protection should be addressed in a broad context. International cooperation at the regional and global levels is essential for creating a broad policy framework to shape and coordinate national measures.

Technical and institutional capacity building, outreach and education

There are several ways to augment the fishing industry's capacity to implement sea turtle avoidance strategies effectively. There are also a number of strategies for ensuring that turtle bycatch avoidance technology is commercially available and for providing fisheries compliance officers with the capacity to identify approved designs and to measure them against approved specifications.

Production and distribution of education and training materials

Several booklets and brochures have been produced outlining turtle bycatch problems and solutions:

- AFMA 2006. *Protected species ID guide*. Australia Fisheries Management Authority.
- Blue Ocean Institute, United Nations Environment Programme Regional Seas Programme, Western Pacific Regional Fishery Management Council, and Indian Ocean – South-East Asian Marine Turtle MoU. 2004. *Catch fish not turtles using longlines.* Honolulu, USA, Blue Ocean Institute and Western Pacific Regional Fishery Management Council.
- NOAA. 2005. *Protected species handling guide*. Brochure produced by NOAA-NMFS, Honolulu, USA.
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There are also videos and DVDs that demonstrate the appropriate post-capture handling of sea turtles:

- Anon. 2004. *Hooks out and cut the line*. A DVD produced by SeaNet-Oceanwatch, Australia
- Canin, J., Henkel, C. & Robins, C. 2005. *Crossing the line: sea turtle handling guidelines for the longline fishing industry*. A DVD produced by Hatchling Productions and Beldi Consultancy, Australia.
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Furthermore, educational programmes have been developed to promote awareness and to educate fishers, fisheries observers and fisheries managers about turtle bycatch problems and solutions. An important lesson that has been learned is that fishers are likely to be most receptive to educational materials and are more likely to change their behaviour if the message focuses on positive results for fishers. For example, fishers are more likely to be receptive to information and to making changes if it can be demonstrated that the changes will increase profits (e.g. changing hook type will increase catch rates of target species).

Training workshops

Workshops and displays of modified gear have been used to increase the capacity of fishers to employ sea turtle bycatch avoidance methods.

Technology, skills transfer and technical support

Technology, skills transfer and technical support are made possible through, for example, government staff exchanges, skipper exchanges, provision of equipment, collaborative research and commercial demonstrations, all of which may help to improve a fishers' capacity to employ sea turtle bycatch avoidance strategies. Furthermore, the Organization for the Promotion of Responsible Tuna Fisheries (OPRT) promotes a grant programme for distributing circle hooks to Japanese longline fishers. The Overseas Fishery Cooperation Foundation (OFCF) has launched a project with the IATTC that will introduce circle hooks to small, coastal longline fisheries.

Financial support for the implementation of guidelines in developing countries

Many of the actions required to mitigate the negative impacts of fisheries on sea turtles are costly. They could have substantial impacts on the livelihoods of fishers and others who are dependent on the fisheries sector. Many developing countries do not have the capacity or the financial resources required to bear such costs.

Although a number of bilateral and multilateral initiatives are under way to develop and implement fishing practices that reduce sea turtle mortality in developing countries, it is essential that these efforts are strengthened and, as far as possible, extended to other countries in need of assistance.

Article 5 of the CCRF stipulates that there is a need to develop mechanisms for directing financial and technical support to developing countries. This may be achieved through the establishment of international cooperative frameworks, voluntary support funds or similar mechanisms that might be incorporated into RFBs. Furthermore, the development of cooperative programmes for sea turtle research and conservation activities may help to direct support to developing countries. For example, RFBs or other IGOs could establish a voluntary support fund or a similar vehicle to provide support to developing countries for the implementation of measures to reduce sea turtle interactions and mortality in marine capture fisheries. The imposition of a bycatch fee or other compensation funds are a possible source of financial support.

Socio-economic and cultural considerations

It is important to take into consideration the social and economic importance of fisheries to coastal communities and national economies. The 2004 FAO Expert Consultation recommended:

- Sea turtle conservation and management programmes should recognize the important contributions of fisheries to employment, income and food security and should be effectively integrated into fisheries management programmes.
- The development, design and implementation of turtle conservation and management measures should take into account the socio-economic aspects of fishers and fishing communities. These communities may be dependent on marine fishery resources for their lives and livelihoods, and a balance should be sought between the conservation and management of sea turtles on the one hand and sustainable livelihoods and poverty alleviation on the other.
- Sea turtle conservation and management programmes should encourage active participation by fishers, fishing communities and other stakeholders. They should include the protection of nesting beaches, fisheries programmes, and should build on traditional knowledge of ecological systems.

The 2004 FAO Expert Consultation also recommended that reliable socio-economic information on fisheries and fishing communities should be collected so that the socio-economic impacts of turtle conservation and management measures can be monitored. For example, longline-caught fish contribute substantially to the economies of some small island states; for some Pacific island states, revenue from tuna longlining is one of the biggest contributors to gross domestic product.

The following guidelines may help countries to take socio-economic aspects into consideration when developing and implementing strategies to reduce sea turtle interactions and mortality in marine capture fisheries:

- Sea turtle conservation programmes should recognize the rights and responsibilities of fishers under international, national and local legal instruments, especially under the 1982 UN Convention on the Law of the Sea, the 1995 UN Fish Stocks Agreement and the 1995 FAO Code of Conduct for Responsible Fisheries.

- Sea turtle conservation and management programmes should encourage active participation by fishers, fishing communities and other stakeholders. They should also build on the traditional ecological knowledge of local communities.
- Efforts should be made to promote sustainable fishing gear and practices that are compatible with turtle conservation and management objectives. Efforts should also be made to minimize dislocation of fishing communities and disruption of their fishing activities.
- There should be training and awareness-building programmes that help fishers to better tackle the problems of sea turtle mortality arising from fishing activities. Training should be aimed at encouraging the effective use of fishing gear that reduces marine turtle mortality.
- Consideration should be given to mechanisms that compensate fishers for lost fishing opportunities as a result of turtle conservation and management measures. These could include free training for fishers to effectively move to, and participate in, fisheries that have minimal interaction with turtles and to provide for alternative employment if fishers would like to leave fishing for other occupations.

Some concrete considerations and examples of indicators that reflect the above principles are:

- The extent to which fishing communities have participated in decision-making processes for turtle conservation and management (number of meetings that are organized; number of meetings that fishers have attended; involvement of women and children; etc.).
- The extent to which traditional knowledge about turtles and turtle-fisheries interactions is documented and used for developing turtle conservation programmes (number of attempts to document traditional knowledge; how far such knowledge is known to be used; etc.).
- The existence of *in situ* studies to understand the interactions between various types of fishing gear and turtles on both temporal and spatial scales (whether there is availability of such studies with increasing frequency or not).
- The extent of cooperation and coordination between different institutions involved in the implementation and enforcement of various legal provisions for turtle conservation and fisheries management.

- The extent to which management agencies have been sensitized to socio-economic issues linked to turtle conservation (e.g. inventory of such meetings shows an increasing trend; proof of joint decision-making and implementation).
- The extent to which public awareness, information and communication programmes in local languages have been developed to highlight the importance of turtles in marine ecosystems (availability of information in local languages and in multimedia format, for example).
- The extent to which fishing communities have been provided with adequate training in hauling, handling and returning turtles to the sea, thereby minimizing incidental mortality of turtles (development of training manuals; inventory of meetings held; documented changes in fishing practices).
- The extent to which programmes have been designed to minimize the socio-economic impact of turtle conservation measures on livelihoods, such as through the provision of subsidies for adopting turtle-friendly fishing gear and practices (number of subsidy schemes for turtle-friendly fishing gear and practices).
- The extent to which compensation mechanisms and alternative employment opportunities have been developed for communities affected by turtle conservation and management measures (number of such schemes in operation).

Reporting

Reporting on the progress of the implementation of these technical guidelines is to be implemented as part of members' biennial reporting to the FAO on the CCRF and, as appropriate and voluntarily, to other relevant bodies such as regional sea turtle conservation and management organizations. The FAO has provided progress reports of actions taken by RFBs and other relevant IGOs to implement the FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations since the Guidelines were developed. Overall, however, FAO has found little formal commitment to, and implementation of, the Guidelines by relevant organizations.

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Glossary of terms

Accidental catch

Or incidental catch: a reference to non-target species captured during their attempts to take bait or other species already taken by fishing gear, or taken simply through being in proximity to the gear.

Allowable catch

The catch allowed by a management authority to be taken from a stock of a species or group of species by a fishery during a specified time period. Often defined as the total allowable catch (TAC), it is often allocated explicitly amongst those having a right of access to the stock.

Area closure

In a fishery management system, the closure to fishing by particular gear(s) of an entire fishing ground, or a part of it, for the protection of a section of the population (e.g. spawners, juveniles), the whole population or several populations. The closure is usually seasonal but it could be permanent.

Area of distribution

Area of distribution is defined (by the CITES) as the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or projected sites of occurrence, excluding cases of vagrancy (although inferring and projecting area of occurrence should be undertaken carefully, and in a precautionary manner). The area should, however, exclude significant areas where the species does not occur, and account should be taken of discontinuities or disjunctions in the spatial distribution of species. For migratory species, the area of distribution is the smallest area essential at any stage for the survival of that species (e.g. colonial nesting sites, feeding sites for migratory taxa, etc.).

Artisanal fisheries

A term of Latin origin with a socio-economic foundation. It tends to imply a simple, individual (self-employed) or family type of enterprise (as opposed to an industrial company), most often operated by the owner (even though the vessels may sometimes belong to the fishmonger or some external investor), with the support of the household. The term has no obvious reference to size but tends to have the same connotation of relatively low levels of technology, and this may not always be the case.

Bycatch

Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying.

Bycatch reduction device

A device inserted in a fishing gear (usually trawl, close to the codend) to allow escape, alive, of unwanted species (including medusae) or individuals (juveniles) or endangered species (e.g. seals, turtles, dolphins).

Catch per unit effort

CPUE. The quantity of fish caught (in number or in weight) with one standard unit of fishing effort, e.g. number of fish taken per 1 000 hooks per day or weight of fish, in tonnes, taken per hour of trawling. CPUE is often considered an index of fish biomass (or abundance). Sometimes referred to as catch rate. CPUE may be used as a measure of economic efficiency of fishing as well as an index of fish abundance. Also called: catch per effort, fishing success, availability.

Closed season

Seasonal closure. The banning of fishing activity (in an area or of an entire fishery) for a few weeks or months, usually to protect juveniles or spawners.

Discard

To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel .

Environmental impact

Direct effect of socio-economic activities and natural events on the components of the environment.

Fish aggregating device (FAD)

Artificial or natural floating objects placed on the ocean surface, often anchored to the bottom, to attract several schooling fish species underneath, thus increasing their catchability.

Fisheries management

The integrated process of information gathering, analysis, planning, decision making, allocation of resources and formulation and enforcement of fishery regulations by which the fisheries management authority controls the present and future behaviours of the interested parties in the fishery, in order to ensure the continued productivity of the living resources.

Front

In oceanographic terms, a region of sharp gradient in temperature or salinity, indicating a transition between two current systems or water masses. Intersection between the thermocline or halocline and the surface. Fronts are usually associated with high biological activity, high abundance of highly migratory resources (e.g. tunas) and are actively sought as fishing areas. Fronts can be monitored by satellite remote sensing.

Gear restriction

A type of input control used as a management tool whereby the amount and/or type of fishing gear used by fishers in a particular fishery is restricted by law.

Incidental catch

The same as accidental or non-target catch.

Industrial fishery

A fishery involving commercial companies using relatively large amounts of capital and energy, relatively large fishing vessels and fishing gear, making long fishery trips, usually offshore.

Monitoring control and surveillance (MCS)

Activities undertaken by the fishery enforcement system to ensure compliance with fishery regulations.

Observer

A certified person onboard fishing vessels that collects scientific and technical information on the fishing operations and the catch for the management authority. Observer programmes can be used for monitoring fishing operations (e.g. areas fished, fishing effort deployed, gear characteristics, catches and species caught, discards, collecting tag returns, etc.).

Selective fishing gear

A gear allowing fishers to capture few (if any) species other than the target species.

Selectivity

Ability to target and capture fish by size and species during harvesting operations, allowing bycatch of juvenile fish and non-target species to escape unharmed.

Target species

Those species that are primarily sought by the fishers in a particular fishery. The subject of directed fishing effort in a fishery.

TED

Turtle excluder device, with inclined grid (or net panel) that allows large animals, such as sea turtles, sharks, rays, jellyfish, sponges and large fish to escape from the trawl.

Vessel monitoring system (VMS)

As part of modern MCS systems, the VMS is a vessel tracking system (usually satellite-based) that provides management authorities with accurate information on fishing vessels' position, course and speed at time intervals. Specifications of VMS approved equipment and operational use will vary with the requirements of the nation of the vessel's registry, and the regional or national waters in which the vessel is operating.