CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Seventy-fourth meeting of the Standing Committee
Lyon (France), 7 - 11 March 2022

THE SCALE AND IMPORTANCE OF MARINE TURTLE BYCATCH RELATING TO TRADE

This document has been submitted by the Secretariat in relation to agenda item 66 on *Marine turtles*.*

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author*

THE SCALE AND IMPORTANCE OF MARINE TURTLE BYCATCH RELATING TO TRADE

OPPORTUNITES FOR PRACTICAL AND EFFECTIVE COLLABORATION BETWEEN CITES, FAO AND RFBS

March 2022

Prepared under contract from the CITES Secretariat by Chris Poonian.

This study has been commissioned by the CITES Secretariat with funding from the United States of America.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AIDCP	Agreement on the International Dolphin Conservation Programme
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CECAF	Fisheries Committee for the Eastern Central Atlantic
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPC	Co-operating non-Contracting Party
FAO	Food and Agriculture Organization (of the United Nations)
GFCM	General Fisheries Commission for the Mediterranean
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IOSEA	Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported and Unregulated
RFB	Regional Fisheries Advisory Bodies
SIOFA	Southern Indian Ocean Fisheries Agreement
SPRFMO	South Pacific Regional Fisheries Management Organisation
TED	Turtle Excluder Device
WCPFC	Western and Central Pacific Fisheries Commission
WECAFC	Western Central Atlantic Fisheries Commission

EXECUTIVE SUMMARY

Sea turtles are globally threatened because of a number of natural and human threats and because of their life history characteristics. Turtle body parts, meat and eggs are of commercial value and illegal national and international trade has further increased exploitation levels. One of the major threats to sea turtles globally is that of interaction with fishing gears across all types and scales of fishery within their ranges, resulting in unintentional bycatch and associated mortality.

This study examined bycatch impacts on turtles globally, with a view to providing opportunities for practical and effective collaboration between CITES, FAO and RFBs on links between bycatch of sea turtles and their international trade.

Small scale fisheries have increasingly been noted as a major cause of turtle bycatch mortality, since these fisheries are generally difficult to regulate and remotely located. However, although turtle bycatch in these turtle fisheries is often retained or indeed actively targeted, it is mainly for subsistence or local use. There is likely a small level of national trade in a number of countries, however international trade is unlikely. It should be noted that there are already established trade routes between remote coastal villages and global markets, for example, shark fins and so these markets could potentially be utilized for sea turtle products if demand increases and customs controls are not sufficient.

The main likely source of turtle products for international trade are Illegal, Unreported and Unregulated (IUU) Fisheries. Since these fisheries are unregulated, the scale of trade of sea turtles in IUU fisheries is unknown. However, bycatch of sea turtles is likely high since there is no requirement for these fisheries to employ mitigation measures.IUU fisheries use transhipment to enable them to move illegal products through international boundaries.

It was found that RFBs on the whole have supported effective bycatch mitigation procedures such as gear modification and fisher awareness-building. As a result, RFBs reported low levels of bycatch mortality in their fisheries and it is unlikely that turtle products are entering international trade from this source. However, there are still gaps in observer coverage and compliance with bycatch measures that should be addressed in order to minimize bycatch mortality.

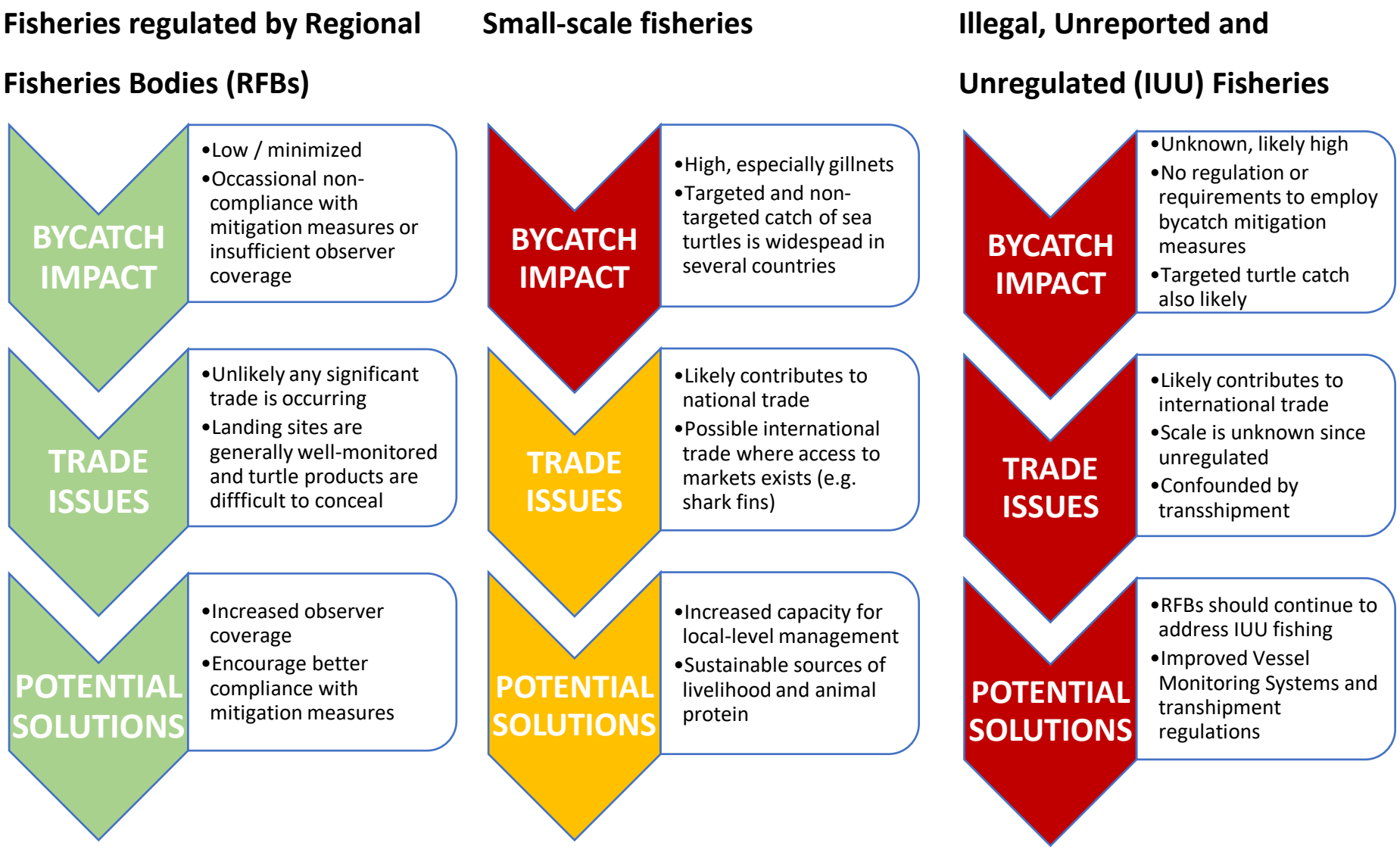

FIGURE 0-1 SUMMARY OF LIKELY BYCATCH IMPACTS, TRADE ISSUES AND POTENTIAL SOLUTIONS. TRAFFIC LIGHT THEME INDICATES CONSERVATION IMPORTANCE AND LEVEL OF INTEREST TO CITES

1 PREAMBLE

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between states. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival (www.cites.org).

In fulfillment of Decision 17.222 paragraph a), the CITES Secretariat prepared a global study (including regional sub-studies) on the legal and illegal international trade in marine turtles. The study entitled *Status, scope and trends of the legal and illegal international trade in marine turtles, its conservation impacts, management options and mitigation priorities* (CoP18 Inf. 18)(CITES Secretariat 2019) investigated the trade in eight countries (Madagascar, Mozambique, Colombia, Nicaragua, Panama, Indonesia, Malaysia and Viet Nam) that had emerged as potentially significant locations involved in illegal trade in marine turtles, following a review of recent literature and consultations with experts [including the International Union for Conservation of Nature Species Survival Commission Marine Turtle Specialist Group (IUCN/SSC MTSG)].

The seven extant species of marine turtles - loggerhead turtle *(Caretta caretta)*, green turtle *(Chelonia mydas)*, leatherback turtle *(Dermochelys coriacea)*, hawksbill turtle *(Eretmochelys imbricata)*, Kemp's ridley turtle *(Lepidochelys kempii)*, olive ridley turtle *(Lepidochelys olivacea)*, and the flatback turtle *(Natator depressus)* - are included in CITES Appendix I and international trade for commercial purposes is strictly prohibited for these species. The study found that in all eight countries, national laws and regulations offered full or partial protection of live animals and their eggs, but marine turtles were being taken as both targeted and non-targeted catch.

The study revealed that levels of bycatch is of concern in several countries because accidentally caught turtles are often retained for consumption and/or trade, but more information is necessary to understand the relationship between bycatch in marine turtles and trade.

Considering the importance of addressing marine turtle bycatch and illegal take in the context of CITES implementation, CoP18 adopted Decision 18.210 paragraph e) that directs the Secretariat, subject to external funding, convey to the Food and Agriculture Organisation of the United Nations (FAO) the findings of the study presented in information document CoP18 Inf. 18 to inform efforts, including by Regional Fisheries Bodies, addressing marine turtle bycatch and illegal take, and promote collaboration, as appropriate.

And in parallel, Decision 18.211 paragraph l) directed to the Parties to: coordinate efforts at the regional level, involving Parties and bodies with relevant mandates, to identify and address trade, use and other threats, such as fisheries' interactions with marine turtles (particularly bycatch), with a view to supporting multilateral environmental agreements.

Understanding the level of marine turtle bycatch and its relationship with trade will provide valuable information to implement the above Decisions and improve and inform existing and future conservation measures for the protection of marine turtles.

1.1 AIMS AND OBJECTIVES

This report aims to:

a) complement and build upon the CITES Secretariat's global study on the legal and illegal international trade in marine turtles to assess the scale and importance of non-targeted catch of marine turtles in trade;
b) contribute to the implementation of Decision 18.210 paragraph e) and Decision 18.211, paragraph l);
c) identify opportunities for practical and effective collaboration between CITES, FAO and Regional Fisheries Bodies (RFBs) to address marine turtle bycatch and trade.

2 INTRODUCTION

2.1 CURRENT STATUS OF SEA TURTLE SPECIES

Sea turtles are long-lived, slow to mature (Mazaris et al. 2005), and particularly vulnerable to poaching on nesting beaches (Koch et al. 2006). All species have suffered declines due to exploitation, fisheries bycatch, and habitat loss. Six of the seven extant species of sea turtle have been prohibited in international trade by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1977, with the seventh species, flatback turtle *(Natator depressus)*, being added to CITES Appendix I in 1981. The Red List of Threatened Species, produced by the International Union for the Conservation of Nature and Natural Resources (IUCN) classifies the global populations of all species, except *N. depressus*, as threatened species (Table 2-1).

TABLE 2-1 IUCN RED LIST THREAT STATUS FOR ALL MARINE TURTLE SPECIES

Common name	Species name	IUCN status
Leatherback turtle	*Dermochelys coriacea*	Critically Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered
Kemp's ridley turtle	*Lepidochelys kempii*	Critically Endangered
Loggerhead turtle	*Caretta caretta*	Endangered
Green turtle	*Chelonia mydas*	Endangered
Olive ridley turtle	*Lepidochelys olivacea*	Vulnerable
Flatback turtle	*Natator depressus*	Data deficient

Although sea turtles are relatively well-studied, management actions and their evaluation are still often hindered by the lack of data on turtle biology, human–turtle interactions, turtle population status and threats. Inter-jurisdictional collaboration is key due to many of the species' wide ranges and significant efforts have been made in recent years to unify conservation efforts (Wold 2002). However, despite initial bleak prospects (Pritchard 1980), turtle populations across the globe are coming back from the brink (Hays 2004; Mazaris et al. 2017). Conservation measures such as bans on direct harvest on nesting beaches and reducing fishery bycatch through gear modification, fishing closures and declining fishing effort appear to have been a resounding success in several cases (Putman et al. 2020).

2.2 TRADE IN SEA TURTLE PRODUCTS

Sea turtle products have been used by humans for thousands of years (Early-Capistrán et al. 2018). In particular, sea turtle shell (tortoiseshell) remains a much sought-after commodity, but also turtle meat and other products (Table 2-2). Evidence from current seizure records and market surveys have highlighted a consistent illegal trade route to mainland China from the Coral Triangle region of South-east Asia (Lam et al. 2012).

TABLE 2-2 USE AND GEOGRAPHICAL FOCUS OF VARIOUS TURTLE PRODUCTS

Product	Use	Key species	Key regions	Reference
Meat Calipée	Food	*C. mydas*	South East Asia Western Indian Ocean	(Frazier 1980; Valverde and Holzwart 2017)
Eggs	Food	All	Widespread South East Asia South America	(Mejías-Balsalobre et al. 2021; Poti et al. 2021)
Carapace	Ornamental	*C. mydas* *E. imbricata*	Widespread	(Lopez and Fallabrino 2001; Quiñones et al. 2017)
Tortoiseshell and scutes	Ornamental	*E. imbricata*	China Japan (bekko)	(Limpus and Miller 1990; Miller et al. 2019)
Skin	Leather	*C. mydas* *L. olivacea*	South America South East Asia	(Mack 1983)
Fat and oil	Food Cosmetics Medicine	All species	Mexico Panama Dominican Republic	(Espinoza et al. 2021)
Lotions and medicine	Medicinal	All species	China Brazil	(da Nóbrega Alves 2006)
Live individuals	Aquaria	*C. mydas* *E. imbricata*	China	(Lin et al. 2021)

2.3 BYCATCH OF SEA TURTLES

The incidental capture or bycatch of sea turtles in fisheries is one of the primary causes of sea turtle mortality globally, leading to population declines and increased risk of local and global extinction (Henwood and Stuntz 1987; Magnuson et al. 1990; Epperly et al. 2002; Lewison et al. 2004, 2014; Finkbeiner et al. 2011; Wallace et al. 2013). Sea turtles interact with a wide variety of fishing gear

because they occupy broad geographic ranges spanning geopolitical boundaries and oceanographic regions, sharing habitat with a variety of fisheries, from small-scale daily subsistence to commercial operations. Bycatch impacts thus vary according to spatio-temporal overlap in fisheries operations and critical habitats associated with various turtle life-history stages, as well as to characteristics of fishing gear (Wallace et al. 2008).

Sea turtle interactions are known to occur in numerous fisheries including pelagic longline, gillnet, set-net, pot, trap, trawl, sea scallop dredge, pound net, purse seine and demersal longline fisheries operating in sea turtle species ranges, primarily in the tropics and subtropics tropics and subtropics (Robins 1995; Cheng and Chen 1997; Gilman et al. 2006, 2007; Koch et al. 2006). Fisheries bycatch is thus a product of susceptibility (driven by the distribution, type, and magnitude of fisheries effort) and vulnerability (based on ecological characteristics of the species; e.g., life history and species distribution).

Sea turtles interact with a variety of fishing gears across their broad geographic distributions and ontogenetic habitat shifts. Thus, there are rarely clear patterns in terms of species-specific vulnerability to bycatch mortality (Wallace et al. 2013). Beyond issues of species viability, declines in marine megafauna lead to major changes in ecosystem function and process (Lewison et al. 2004). Fisheries bycatch is a major driver of trophic downgrading which has reverberating effects on biotic interactions, disturbance regimes, species invasions, and nutrient cycling (Lewison et al. 2014).

Fisheries managers initially recognized turtle bycatch as a conservation issue because of significant mortalities in industrial shrimp trawlers, leading to gear modifications and the development of turtle excluder devices (TEDs) (Crowder et al. 1994). Since then, industrial pelagic longlines have been recognized as a key gear for incidental interactions with turtles through hooking and entanglement (Lewison and Crowder 2007) More recently, less-studied small scale fisheries have been noted to likely contribute substantially to global bycatch mortality of marine megafauna including turtles (Moore et al. 2010).

Considering the value of sea turtle products, there is a risk that bycaught animals could enter international markets from a variety of fisheries. This report analyses the magnitude of sea turtle bycatch in various fisheries, current management and mitigation measures and potential for links between bycatch and trade in order to provide recommendations to CITES, RFBs and the FAO for collaboration opportunities.

3 LEVELS OF MARINE TURTLE BYCATCH

3.1 INTRODUCTION

The magnitude of sea turtle bycatch for a given area is dependent on several factors, the most pertinent being:

- fishing method and gear characteristics (Wallace et al. 2008, 2010; Lewison et al. 2009)
- species' life history and ecology (Žydelis et al. 2009)
- overlap between fishing activities and critical habitat for a given population (Peckham et al. 2007; Žydelis et al. 2011)

In order to accurately estimate bycatch rates, it is essential to determine the bycatch rate per gear or vessel and the amount of fishing effort on which these rates were based. The actual rate of mortality is also essential to determine in order to understand the likely effects on the overall sea turtle population. However, even in regulated fisheries, regulatory observers are often only present for less than 5% of total fishing effort in a particular fishery (Wallace et al. 2010; Finkbeiner et al. 2011). Furthermore, observers are rare in small-scale fisheries and inherently absent in Illegal, Unreported and Unregulated (IUU) fisheries.

Further difficulties are encountered because bycatch is a rare event relative to overall fishing effort, and the amount of effort observed, analogous to survey effort, can affect observed bycatch rates (Sims et al. 2008). Bycatch studies often focus on specific areas, fisheries and times, limiting their general application, particularly for wide-ranging species such as sea turtles (Lewison et al. 2009). Population characteristics of widely distributed marine species can vary significantly across geographic regions and this information is essential to understand wider ecosystem and population effects (Suryan et al. 2009).

Individual turtle populations can interact with several fisheries across their range, so cumulative impacts of these fisheries must be considered and management practices integrated across regional management bodies (Wallace et al. 2008, 2010; Moore et al. 2009). It is also necessary to understand impacts in terms of both turtle mortality and alteration of marine communities (Lewison et al. 2004). Ultimately, mitigating sea turtle bycatch involves the development of technical modifications to gear and creating policy strategies compatible with socio-economic needs (Shiode and Tokai 2004).

3.2 CURRENT ESTIMATES OF CAPTURES AND MORTALITY

3.2.1 FISHERIES REGULATED BY REGIONAL FISHERIES BODIES (RFBS)

The FAO Technical Consultation on Sea Turtles Conservation and Fisheries (2004) identified priority sea turtle populations thought to be at risk from bycatch and encouraged RFBs to collect data on bycatch including rates of bycatch and species distributions as well as to introduce gear modifications in order to mitigate bycatch of turtles, particularly in coastal fisheries and pelagic longlines. The implementation of bycatch mitigation measures since the 1990s have broadly been successful in regulated fisheries (Table 3-1). Most of the RFBs consulted during this study reported compliance with bycatch measures and relatively low bycatch of sea turtles.

3.2.1.1 INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS (ICCAT)

ICCAT longline fishing poses the greater threat to turtles than purse seining. Loggerhead and leatherback turtles potentially encounter the most longline fishing effort (~300 million and >650 million hooks/yr, respectively). The east Atlantic olive ridley, the south Caribbean green turtle and SW Atlantic leatherback turtle populations were consistently among the most vulnerable from both gear types. Conversely, the west Atlantic olive ridley turtles showed lowest risk (Angel et al. 2014). Regions where turtles are at highest risk included Southern Caribbean and tropics (20°N-15°S, both gear types), and loggerhead turtles in the Mediterranean (longline only) (Coelho et al. 2013; Angel et al. 2014).

3.2.1.2 INDIAN OCEAN TUNA COMMISSION (IOTC)

In the IOTC region, coastal fisheries, mainly gillnets, seem to have the highest impact on sea turtles, particularly *C. mydas*; coastal species such as *C. mydas* and *E. imbricata* are the species most threatened by bycatch in trawl fisheries, whereas the more pelagic *C. caretta and D. coriacea* are most threatened by bycatch in longlines (Bourjea et al. 2008). Purse seiners are thought to be responsible for only a low level of bycatch (Amandé et al. 2008).

3.2.1.3 WESTERN AND CENTRAL PACIFIC FISHERIES COMMISSION (WCPFC)

Low levels of sea turtle bycatch have been reported in several fisheries including the Hawaii longline fishery, the tuna longline fishery and the Eastern tuna and billfish fishery (WCPFC 2009).

3.2.1.4 INTER-AMERICAN TROPICAL TUNA COMMISSION (IATTC)

Interactions between sea turtles and the fisheries that IATTC regulates are rare and the vast majority of them are released alive (pers comm. Jon Lopez).

TABLE 3-1 ESTIMATED ATLANTIC AND PACIFIC MEAN ANNUAL SEA TURTLE BYCATCH AND MORTALITY (SORTED BY INDIVIDUAL FISHERIES) BETWEEN 1990 AND 2007 (FINKBEINER ET AL. 2011)

Fishery	Pre-regulation mean	Pre-regulation range	Post-regulation mean	Post-regulation range
Atlantic bycatch interactions				
SE/Gulf of Mexico Shrimp Trawl	340,500	NA	133,400	NA
Atlantic/Gulf of Mexico Pelagic Longline	1600	414–3553	1400	625–2143
Mid-Atlantic Bottom Trawl	1100	NA	600	NA
Virginia Pound Net	600	NA	600	NA
Gulf of Mexico Reef Fish	600	NA	600	NA
Mid-Atlantic Gillnet	400	43–1018	300	154–465
NC Pound Net	200	129–355	200	194–269
SE Demersal Shark Longline	200	107–339	200	107–339
Mid-Atlantic Scallop Trawl	100	NA	100	NA
NC Inshore Gillnet	100	28–275	100	28–275
SE Snapper/Grouper	100	NA	100	NA
Mid-Atlantic Scallop Dredge	300	74–749	90	0–180
Gulf of Mexico Hook and Line	10	NA	10	NA
SE Shark Drift Gillnet	<10	0–19	<10	0–19
Pacific bycatch interactions				
HI Pelagic Shallow & Deep Set Longline	700	601–849	100	3–558
CA Set Gillnet	10	0–43	10	0–43
CA/OR Drift Gillnet	30	6–102	<10	0–29
CA Pelagic Deep Set Longline	<10	NA	<10	NA
Atlantic mortality events				
SE/Gulf of Mexico Shrimp Trawl	69,300	NA	3700	NA
Mid-Atlantic Bottom Trawl	200	NA	300	NA
Gulf of Mexico Reef Fish	200	NA	200	NA
Mid-Atlantic Gillnet	200	17–407	100	62–186
Mid-Atlantic Scallop Dredge	600	NA	70	0–135
SE Demersal Shark Longline	50	15–97	50	15–97
SE Snapper/Gouper	40	NA	40	NA
NC Inshore Gillnet	30	0–84	30	0–84
Atlantic/Gulf of Mexico Pelagic Longline	100	0–726	20	0–50
Virginia Pound Net	<10	NA	<10	NA
SE Shark Drift Gillnet	<10	0–3	<10	0–3
Gulf of Mexico Hook and Line	0	NA	0	NA
NC Pound Net[a]	0	NA	0	NA
Mid-Atlantic Scallop Trawl	0	NA	0	NA
Pacific mortality events				
HI Pelagic Shallow and Deep Set Longline	300	245–359	50	0–251
CA/OR Drift Gillnet	20	0–40	<10	0–19
CA Set Gillnet	<10	0–30	<10	0–30
CA Pelagic Deep Set Longline	<10	NA	<10	NA

3.2.1.5 SOUTH PACIFIC REGIONAL FISHERIES MANAGEMENT ORGANISATION (SPRFMO)

Bycatch records are sparse within the SPRFMO's jurisdiction and only two bycatch incidents involving sea turtles have been recorded. One *C. mydas* in 2016 from the Australian longline fishery which operates around 750,000 hooks per year and one from the Chinese squid jig fishery in 2020-2021 which was released alive (Craig Loveridge pers comm).

3.2.2 SMALL SCALE FISHERIES

The magnitude of bycatch of sea turtles in small scale fisheries (SSFs) has only been considered in recent years, however evidence is emerging that these, often less-regulated fisheries could be substantial contributors to sea turtle mortality, both through bycatch and targeted catch (Moore et al. 2010). Coastal artisanal and small domestic longline fleets which set shallow gear may also cause relatively high sea turtle mortality and thereby impact populations of critically threatened turtles. This is as a result of the location of their fishing grounds and their fishing methods and gear. For instance, 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 (Martínez-Ortiz et al. 2015). 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 artisanal, longline fisheries have been documented. Sea turtle exploitation is also widespread in the Indian Ocean and often linked to fisheries (Frazier 1980).

3.2.3 ILLEGAL, UNREPORTED AND UNREGULATED (IUU) FISHERIES

The FAO defines IUU fishing as follows: Illegal, unreported and unregulated (IUU) fishing is a broad term that captures a wide variety of fishing activity. IUU fishing is found in all types and dimensions of fisheries; it occurs both on the high seas and in areas within national jurisdiction. It concerns all aspects and stages of the capture and utilization of fish, and it may sometimes be associated with organized crime. Illegal, unreported and unregulated (IUU) fishing may pose a threat to sea turtles, as IUU vessels are unlikely to employ measures to reduce sea turtle interactions and mortality.
However, by their very nature, it is almost impossible to estimate catches of sea turtles in IUU fisheries beyond anecdotal data.

IUU fishing has been reported in the Indian Ocean (Anganuzzi 2004; Beri 2011) and it has been reported as a likely widespread source of sea turtle bycatch in the region (Bourjea et al. 2008; Riskas

et al. 2018). However most of the turtles caught here are likely for local subsistence and minimal national trade (

Table 3-2). The most significant likely link between sea turtle bycatch in IUU fisheries and international trade occurs in Southeast Asia (

Table 3-2). Green and hawksbill turtles are reported to be caught by fishers using beach collection during nesting, in-water techniques using spear guns and long-line fishing, as well as by-catch from fishing nets and dynamite fishing (Schoppe and Antonio 2009). Turtles are purchased by Chinese dealers, mainly from the Hainan province and China, Japan and Taiwan, Province of China are the intended end destinations for whole turtles harvested illegally in Southeast Asia (CMS and IOSEA 2016). Following the contraction of a large-scale wholesale export market in Viet Nam , as a result of a domestic ban enacted in 2002, much of the Vietnamese turtle catch was subsequently reported to be traded directly at sea in exchange for commodities brought on vessels from Hainan (CMS and IOSEA 2016). Numerous seizures in Viet Nam, including of hawksbill turtles, seem to suggest that Indonesia and Malaysia could still be a source of raw scutes used in *bekko* manufacture (Stiles 2008; CMS and IOSEA 2016).

Transhipment at sea (transferring cargo from one vessel to another, including over international borders) of illegally-caught turtles is also confirmed to happen in several countries within these sub-regions: China, Indonesia, Malaysia, Philippines and Viet Nam in Southeast Asia; and Kenya, Tanzania and Mozambique in Southwestern Indian Ocean (Riskas et al. 2018). Transhipment may play an important role in facilitating the exploitation of sea turtles for commercial purposes. As noted above, transhipment of sea turtles by Chinese and Vietnamese poachers in the South China Sea has been reported. In Kenya and Mozambique, foreign vessels target sea turtles, with transhipment at sea confirmed to occur for illegally-caught turtles in Kenya, Mozambique and Tanzania (Riskas et al. 2018).

TABLE 3-2 IMPACTS OF IUU FISHERIES ON SEA TURTLES (RISKAS ET AL. 2018)

Sub-region	Magnitude of IUU by foreign and domestic vessels	Primary vessel type	Location of IUU incidents	Turtle species (top 2)	Fate of turtles (top 2)
Southwestern Indian Ocean (*SWIO*)	Foreign IUU: widespread, significant problem (56%) Domestic IUU: widespread, significant problem (56%)	Domestic artisanal (66%)	Within EEZs (94%)	Green (50%) Hawksbill (50%)	Used for food (52%); sold locally (24%)
Northwestern Indian Ocean (*NWIO*)	Foreign IUU: isolated incidents, not a significant problem (50%) Domestic IUU: widespread, significant problem (40%)	Domestic artisanal (50%)	Within EEZs (90%)	Green (50%) Hawksbill (40%)	Released alive (35%); used for food (35%)
Northern Indian Ocean (*NIO*)	Foreign IUU: isolated incidents, not a significant problem (50%) Domestic IUU: widespread, significant problem (67%)	Domestic artisanal (89%)	Within EEZs (89%)	Olive ridley (78%) Green, loggerhead (11%)	Released alive (56%); used for food (22%)
Southeast Asia (*SEA*)	Foreign: widespread, significant problem (36%) Domestic: isolated incidents, significant problem (36%)	Domestic artisanal (57%)	Within EEZs (64%)	Green (64%) Hawksbill (57%)	Sold locally (36%); shipped overseas (36%)
All IOSEA	Foreign: widespread, significant problem (37%) Domestic: widespread, significant problem (47%)	Domestic artisanal (56%)	Within EEZs (92%)	Green (47%) Hawksbill (35%)	Used for food (36%); sold locally (24%)

4 EXISTING REGULATORY AND MONITORING MECHANISMS

4.1 MITIGATION APPROACHES

Measures to mitigate sea turtle bycatch mortality employed to date have primarily involved technical modifications to gear (including bait) and fishing methods, mainly in industrial fisheries (Broadhurst 2000; Bolten and Bjorndal 2003; Kennelly and Broadhurst 2021). These modifications must take into account the size and species of turtle, the target species and vessel size and design. There are a number of other approaches that should also be considered in a comprehensive bycatch mitigation programme including:

- area restrictions or seasonal restrictions on fishing operations;
- voluntary communication between vessels 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;
- post-capture practices that can improve the survival prospects of sea turtles after release;
- avoiding the loss and discarding of fishing gear and other debris; and
- retrieving derelict fishing gear and other debris at sea.

Fishers' cooperation is essential for any of these measures to be successful and so the human dimension such as education programmes and socioeconomic considerations must also be included (Campbell and Cornwell 2008). Fishers are likely to have valuable knowledge and information relating to sea turtle bycatch and their knowledge can be helpful in finding effective and practical solutions (Costanza et al. 2021). Methods that are shown to be effective in reducing turtle bycatch may not be employed if they are not convenient and economically viable and so market-based and other policy instruments should be considered (Dutton and Squires 2008). All of these approaches must also be supported by national legislation and international agreements.

4.1.1 SHRIMP TRAWLS AND TURTLE EXCLUDER DEVICES (TEDS)

In 1991, the United States of America began enforcing an embargo on all shrimp imports from countries that did not use shrimp trawl nets equipped with TEDs and the FAO encourages the use of TEDs in shrimp trawl fisheries. The most common TED designs use an inclined grid to prevent large animals from entering the codend (Figure 4-1). 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 or in the top of the codend. 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.

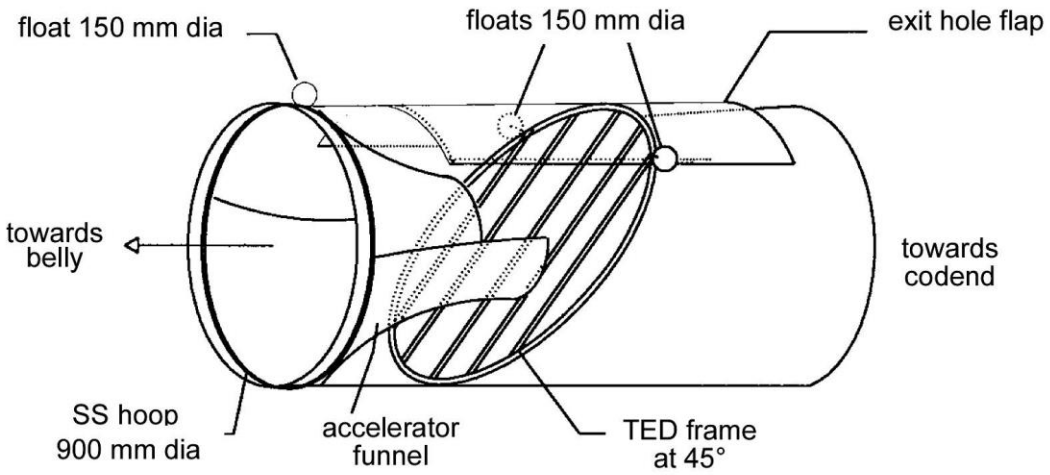

FIGURE 4-1 TURTLE EXCLUDER DEVICE (TED) (BOOPENDRANATH ET AL. 2010)

4.1.2 LONGLINES

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. These fisheries targeting large tunas (*Thunnus* spp.), swordfish (*Xiphus gladius),* other billfishes (Istiorphoridae), and dolphinfish (mahimahi, *Coryphaena* spp.) have commonly been associated with sea turtle interactions, particularly *C. Caretta* and *D. coriacea* (Lewison and Crowder 2007).

Longlines commonly consist of a long main line from which individual hooks are suspended at intervals of 80 to 120 m. They can be up to 100 km long and carry up to 3500 barbed hooks. The hooks are attached to the main line by monofilament branch- lines or gangions. Floats attached to branch-lines are spaced along the main line to keep it elevated horizontally in the water, and the branch lines hang vertically from it. A variety of bait is used, with whole smaller fish, such as Atlantic mackerel and squid.

Longlines can be set to hang at varying depths depending on the targeted species. Hooks set in the upper 100 m of the water column, often targeting swordfish, are believed to have an order of magnitude higher sea turtle interaction rate than deeper sets because these depths are also more commonly frequented by turtles (Howell et al. 2008). Use of mitigation measures is therefore most urgent for shallower longline fisheries in areas where sea turtles occur and during times and seasons when they are particularly abundant.

There are several fishing methods and gear modifications that have been shown to significantly reduce sea turtle interactions in longline fisheries without compromising catch rates of target species (Swimmer et al. 2017). These methods include:

- using wide circle hooks;
- using fish rather than squid for bait; and
- setting hooks deeper than 100 m

4.1.3 GILLNETS

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. 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 (Cheng and Chen 1997; Murray 2009). Pelagic drift nets are sometimes lost and become 'ghost' nets but in most cases lost nets collapse into bundles and are relatively low-risk to sea turtles.

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 (Northridge et al. 2017).

The low profile technique has also proved effective at reducing turtle interactions in surface gillnet fisheries (He and Jones 2013). 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 %

reduction in leatherback bycatch rates through the use of lower profile nets (Gilman et al. 2010). 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 (Murray 2009; Wang et al. 2010). 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.

4.1.4 Purse Seines

Purse seines are designed to catch schooling fish and consist of 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 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.

Sea turtles are occasionally caught in purse seine, but interactions are low compared to gillnets ad longlines (Romanov 2002). Most interactions occur when the turtles associate with floating objects (for the most part fish-aggregating devices (FADs)), and are captured when the object is encircled.

Possible mitigation measures recommended to the industry are:

- avoid the encirclement of sea turtles, wherever practical;
- if encircled or entangled, take all possible measures to safely release turtles;
- 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;
- develop modified FAD designs to reduce and eliminate sea turtle entanglement;
- implement successful methods identified through research and development.

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

- 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.
- 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.
- 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.

4.1.5 TURTLE HANDLING GUIDELINES

A high proportion of turtles can survive the gear soak and are alive when brought to the vessel during gear hauling. Efforts to minimize injury to turtles likely increase the turtle's ability to survive the interaction with fishing gear. Several sea turtle handling and release guidelines have been published (FAO and ACCOBAMS 2018; NOAA 2019).

4.2 REGIONAL FISHERIES BODIES (RFBS)

The need for regional, international cooperation for the proper management of common fishery resources has led to the establishment of Regional Fishery Bodies (RFB's) in all regions of the world where fishing is undertaken. The 100 years since the establishment of the first RFB (International Council for the Exploration of the Sea, ICES) in 1902 can be generally divided into three periods.

While RFB's established during the first period (before the UN negotiations on the Law of the Sea (UNCLOS) in the 1950s), emphasised scientific data collection and collaboration (e.g. ICES), most bodies established during the UNCLOS negotiations have advisory and/or regulatory powers, while most RFB's established since the 1982 Law of the Sea Convention in 1982 have clear management functions. The gradual change of focus began with the creation of the FAO as a specialized agency of the United Nations in 1945. The FAO is now the principal umbrella organization responsible for the coordination of fishery management measures undertaken by regional and national fishery bodies.

Of the 27 RFB's currently active, seven have been established either under Article VI or XIV of the FAO Constitution. These subsidiary FAO bodies have only advisory functions, and do not have any regulatory powers. The FAO has also facilitated and assisted in the establishment of many of the other RFB's and serves as the depositary for the instrument of acceptance of such bodies. While some RFB's have mandates covering specific geographic areas, others are concerned with the conservation and management of specific species of groups of species.

There are several RFBs 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. Though 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 following subsections gives a description of relevant actions taken by individual RFBs and current approaches to the management and mitigation of sea turtle bycatch. As noted, in addition to the need for collaboration in relation to target species where there is explicit, physical overlap there is also a need for collaboration on non-target and associated or dependent species. Highly migratory species, such as marine turtles regularly migrate through the waters of two or more RFBs, and therefore coordinated conservation measures are vital. For example, species such as the *D. coriacea* and *C. caretta* are pan-Pacific in nature and threatened by fisheries, whether longline or purse seine, and thus co-operation is required between the Southern Pacific Regional Fisheries Management Organization (SPRFMO), Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) on mitigation measures.

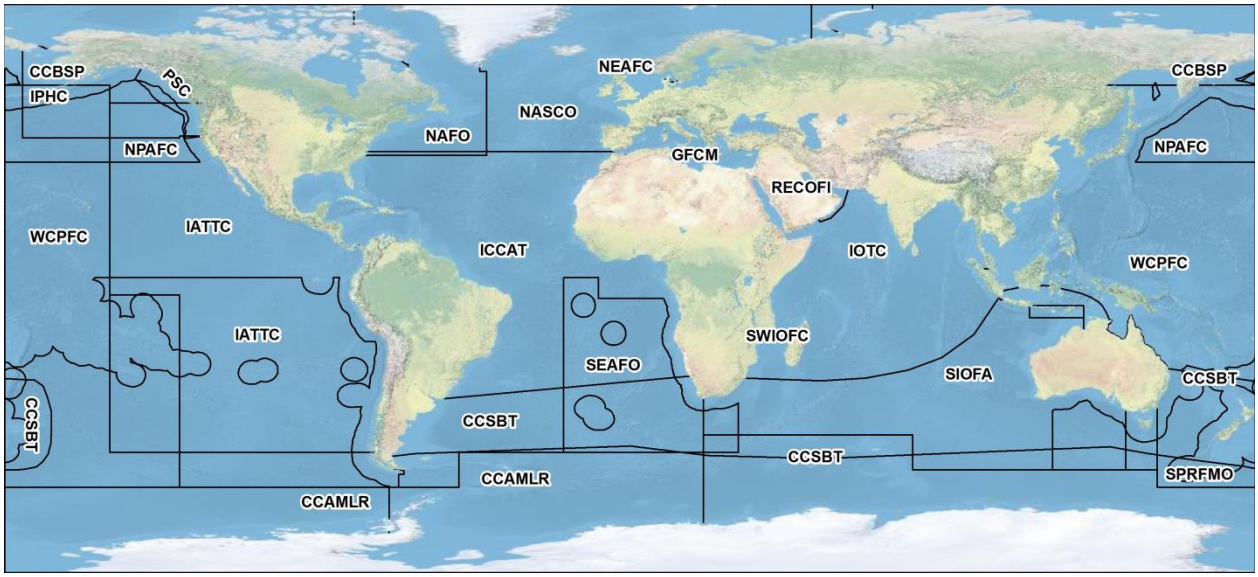

FIGURE 4-2 JURISDICTIONS OF REGIONAL FISHERY BODIES (RFB) (SOURCE: FAO HTTPS://WWW.FAO.ORG/FISHERY/EN/RFB)

4.2.1 INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS (ICCAT)

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is responsible for the study of the populations of tuna and tuna-like species and other species exploited in tuna fishing in

the Convention area (Figure 4-2) including research on the abundance, biometry and ecology of the fishes; the oceanography of their environment; and the effects of natural and human factors upon their abundance. The ICCAT was established to address the concerns of overfishing and the clear need to manage tuna stocks sustainably. In the ICCAT region, longlining and purse seining are the primary gears used to capture tunas. Gillnet effort represents 2 % and the fishery is data-poor, even though this gear is known to be responsible for high rates of turtle bycatch (Lewison and Crowder 2007). Species other than the 12 main targeted tuna, swordfish, and shark species are reported voluntarily as weights or numbers landed or discarded along with corresponding fishing effort. The ICCAT has adopted the following resolutions relevant to sea turtle bycatch:

- Resolution 05-08 on circle hooks, encouraging the use of and reaserch into circle hooks and other gear modifications;
- Recommendation 10-09 on the bycatch of Sea Turtles in ICCAT Fisheries which focuses on data collection, safe handling and release;
- Recommendation 13-11 Amending Recommendation 10-09 on the bycatch of Sea Turtles in ICCAT Fisheries which provides further detail on safe handling practices and use of line cutters.

4.2.2 INDIAN OCEAN TUNA COMMISSION (IOTC)

The Indian Ocean Tuna Commission (IOTC) is the main regional fisheries management organization mandated to manage tuna and tuna-like species in the Indian Ocean and adjacent seas. While its primary objective is to assure the conservation and optimum utilization of fish stocks, the IOTC has paid increasing attention in recent years to the impacts of its fisheries on other marine species, such as marine turtles, seabirds and sharks.

IOTC Resolution 12/04 (adopted in April 2012) requires IOTC Contracting Parties and Co-operating non-Contracting Parties (CPCs) to take various measures in order to mitigate the impact of their fisheries on the six species of marine turtles that are present in the Indian Ocean. The requirements of CPCs with regard to fishing vessels registered on the IOTC Record of Fishing Vessels can be summarized as follows: - To require fishermen to bring aboard, if practicable, any captured marine turtle that is comatose or inactive, and foster its recovery before safely returning it to the water; and to release marine turtles observed entangled in fishing gear; - To ensure that fishermen are aware of and use proper mitigation, identification, handling and dehooking techniques and keep on board all necessary equipment for the release of marine turtles. More specifically, CPCs are to ensure that longline vessel operators carry line-cutters and de-hookers; that purse seine vessel operators avoid encirclement of marine turtles and use dip nets to handle them; and they are encouraged to adopt

designs for Fish Aggregating Devices (FADs) that reduce the incidence of entanglement of marine turtles; and - To collect, and provide to the IOTC Secretariat, all data on their vessels' interactions with marine turtles, through the use of a logbook system and an observer programme.

CPCs are also requested to undertake research trials with a view to improving mitigation methods in several areas that have shown potential (e.g. use of circle hooks and whole finfish bait, alternative gear design and handling techniques) and to report the results of these trials to the Scientific Committee. Furthermore, CPCs are encouraged to collaborate with IOSEA, to apply the FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations, and to support developing countries in their implementation of these guidelines. The provisions of Resolution 12/04 are broadly shared by its predecessor from 2009, Resolution 09/06, with the introduction of some additional elements. For instance, the new resolution clarifies that it applies to all fishing vessels on the IOTC Record of Fishing Vessels, and reinforces the need for CPCs to report annually to the IOTC Secretariat all interactions and mortality of marine turtles in fisheries under the IOTC mandate. As noted above, the latest resolution also calls for the development of improved FAD designs to reduce the incidence of entanglement of marine turtles; and its provisions on safe handling of accidentally captured marine turtles now apply to all species, not only hard shelled turtles. Similarly, IOTC Recommendation 05/08, dating back to 2005, also included specific guidelines in relation to safe handling, purse seine and longline operations, and data collection.

According to the IOTC 2012 national reports, 14 CPCs currently apply a system of turtle bycatch monitoring to a portion of their fisheries. Such activities are organised either as part of their main observer programme (Australia), logbook system (China), other research projects carried out by specialized institutes (EU countries), or by NGOs (Seychelles). On the other hand, seven countries (Comoros, Kenya, Madagascar, Mauritius, Oman, Philippines, and Thailand) did not provide any data in their IOTC reports, suggesting no existing monitoring activities. The United Kingdom (BIOT) and Maldives declared no turtle bycatch in their waters due to the nature of their fisheries in 2011, without specifying whether monitoring had been implemented for that year or not. Among the CPCs reporting on levels of turtle bycatch, Australia, China, Mozambique and Spain reported no interaction of their national fisheries with marine turtles in 2011, in the IOTC area. The number of incidentally caught turtles averaged about 12 in countries reporting incidental catch events in their territorial waters for that year (10 for Portugal, 14 for Japan, and 12 for South Africa).

Very few CPCs provide information on the fate of by-caught turtles in their IOTC, IOSEA or other reports. Some reports suggest that a high percentage of turtles may be released alive. For example, the study by Clermont et al (2012) indicates that 86% of the nearly 600 turtles caught in the EU purse seine fishery between 2003 and 2010 were released alive. A similarly high value, 88%, was reported for one of Australia's eastern longline fisheries, based on a much smaller sample size (22 animals).

4.2.3 Western and Central Pacific Fisheries Commission (WCPFC)

The Western and Central Pacific Fisheries Commission (WCPFC) was established by the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention) which entered into force on 19 June 2004. The WCPFC adopted Resolution 2018/04 (Conservation and Management Measure of Sea Turtles) at its 15th regular session 10-14 December 2018. The measures include: implementation of FAO safe handling recommendations, resuscitation of bycaught turtles and reporting of all data collected on sea turtle interactions. The measures are specific to longline and purse seine vessels including the use of circle hooks, finfish bait availability of line-cutters and de-hookers, minimum observer coverage and avoidance of turtles when deploying nets. There has been variation in Commission Members, Cooperating non-Members and participating Territories (CCMs) willingness to implement these measures, and China and Indonesia currently non compliant for purse seiners and Indonesia for long liners.

4.2.4 Inter-American Tropical Tuna Commission (IATTC)

The Inter-American Tropical Tuna Commission (IATTC) was established in 1949 with the aim to conserve and manage tuna and other marine resources in the eastern Pacific Ocean (Figure 4-2).

Additionally, contracting parties and co-operating non-parties (CPCs) have agreed (Resolution C-07-03) to implement the FAO Guidelines to reduce mortality and injury of turtles together with adjustments to fishing practices with purse seines and longlines. They have also agreed (Resolution C-05-01) to take steps to reduce incidental catches of seabirds taking into account the FAO International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries, and to conserve and manage shark stocks in accordance with the FAO International Plan of Action for the Conservation and Management of Sharks (Resolution C-05-03).

The Agreement on the International Dolphin Conservation Programme (AIDCP) (sister organisation to IATTC) has references to sea turtles and the bycatch measures applicable to multiple species. The AIDCP has shown how effective bycatch mitigation measures can be since it has reduced dolphin

catches per set from more than 8 individuals per set in the 1980s to almost zero from 2000. This has been achieved by observers, 'Dolphin Mortality Limits' assigned to individual vessels, and changes to fishing practices and gear.

4.2.5 COMMISSION FOR THE CONSERVATION OF SOUTHERN BLUEFIN TUNA (CCSBT)

The CCSBT has agreed to a variety of binding and non-binding measures related to mitigation of bycatch.

In accordance with the Resolution to Align CCSBT's Ecologically Related Species measures with those of other tuna RFBs (Adopted October 2018, revised October 2019, October 2020 and October 2021), the following measures of IOTC, WCPFC, or ICCAT are binding on Members of the CCSBT when fishing within the relevant area of competence:

Area of Competence of the IOTC

- Resolution 12/04 On the conservation of marine turtles;

Convention Area of the WCPFC

- Resolution 2018/04 - Conservation and Management Measure of Sea Turtles;

Convention Area of the ICCAT

- Resolution 05-08 on circle hooks;
- Recommendation 10-09 on the By-catch of Sea Turtles in ICCAT Fisheries;
- Recommendation 13-11 Amending Recommendation 10-09 on the By-Catch of Sea Turtles in ICCAT Fisheries.

In addition, in accordance with CCSBT's Recommendation to Mitigate the Impact on Ecologically Related Species of Fishing for Southern Bluefin Tuna (Revised October 2019), Members will, to the extent possible, implement the FAO Guidelines to reduce sea turtle mortality in fishing operations (FAO-Sea turtles), if they have not already done so.

4.2.6 SOUTH PACIFIC REGIONAL FISHERIES MANAGEMENT ORGANISATION (SPRFMO)

The South Pacific Regional Fisheries Management Organisation (SPRFMO), established in 2013 is an inter-governmental organisation that is committed to the long-term conservation and sustainable use of the fishery resources of the South Pacific Ocean and, in so doing, safeguarding the marine ecosystems in which the resources occur. The SPRFMO Convention applies to the high seas of the South Pacific, covering about a fourth of the Earth's high seas areas and currently includes 15 Members from Asia, Europe, the Americas, and Oceania. Currently, the main commercial resources fished in the SPRFMO Area are Jack mackerel and jumbo flying squid in the Southeast Pacific and, to

a much lesser degree, deep-sea species often associated with seamounts in the Southwest Pacific. The Organisation consists of a Commission and a number of subsidiary bodies. New Zealand is the Depositary for the SPRFMO Convention and hosts the SPRFMO Secretariat in Wellington.

Sea turtles are regarded as an SPRFMO species of concern and are highlighted throughout its data standards (Jim Ianelli pers comm.). The commission currently aims to implement more effective and comprehensive bycatch data collection and reporting and the extension of data collection programmes to include environmental data and other data to assist in estimating potential impacts on non-target species (Ridings et al. 2018).

4.2.7 General Fisheries Commission for the Mediterranean (GFCM)

The General Fisheries Commission for the Mediterranean (GFCM) includes the Mediterranean and the Black Sea and connecting waters (Figure 4-2). GFCM's objectives include

- promoting the development, conservation and management of living marine resources;
- formulating and recommending conservation measures; and
- encouraging training and cooperative projects.

Medbycatch project aims to build on complementarities of partners' respective mandates, while joining resources and expertise and striving for best practices and replicability, the Med bycatch project aims to:

- Address knowledge gaps regarding the bycatch of vulnerable species occurring during fishing operations in the Mediterranean through a more systematic and standardized approach to data collection and capacity-building.
- Identify, and support the testing of, mitigation measures to reduce incidental catches and/or mortality of vulnerable species.
- Raise awareness on the issue of bycatch and provide bases for the formulation of national/regional strategies to reduce incidental catches, preserve vulnerable species and support the sustainability of fisheries.

4.2.8 Western Central Atlantic Fisheries Commission (WECAFC)

FAO presented the draft regional strategy on the management of bycatch and discards in Latin American and Caribbean bottom trawl (shrimp and groundfish) fisheries. REBYC-II LAC project countries requested that WECAFC leads a strategy on bycatch management in trawl fisheries that ensure a common approach across borders. REBYC-II LAC partners also considered that this

mechanism benefits as well countries not directly involved in the project, for consistency with a key recommendation of the FAO International Guidelines on Bycatch Management and Reduction of Discards.

The strategy objectives are:

- apply an ecosystem approach for the management of bycatch and discards;
- improve data collection and monitoring procedures;
- reduce unsustainable bycatch with Turtle Excluder Devices (TED) and Bycatch Reduction Devices (BRD);
- mainstream the use of spatial and temporal measures,
- utilize sustainable bycatch;
- strengthened communication, coordination and information sharing.

4.3 Regional Turtle Agreements

4.3.1 Indian Ocean South East Asia Memorandum of Understanding (IOSEA)

At their Seventh Meeting (Bonn, September 2014), the Signatory States to the IOSEA Marine Turtle MoU identified a need to increase the visibility of issues concerning interactions of fisheries with marine turtles in the Indian Ocean and South-East Asia region. IOSEA has a strong working relationship with RFMOs in the region and has collaborated particularly closely with IOTC to evaluate bycatch issues in the region (Hykle 2013).

4.3.2 SPAW-RAC

The SPAW Protocol has established a Scientific and Technical Advisory Committee (STAC) to address issues and identify priorities regarding Protocol implementation which meets biannually with the meetings of the Parties. This mechanism provides a platform useful for governments, scientists and NGOs to discuss and reach consensus on priority biodiversity issues and initiatives.

Major areas of work of SPAW Sub-programme include

- Marine Protected Areas strengthening, capacity building and networking through SPAW's Caribbean Marine Protected Areas Management Network and Forum (CaMPAM).
- Listing of protected areas under the SPAW Protocol and a cooperation programme for those sites

- Ecosystem based management, focusing on coral reefs and valuation of environmental services of coastal ecosystems
- Species recovery and management. Threatened species (e.g. sea turtles, marine mammals, migratory birds) and species requiring sustainable use (lobster, conch, targeted fish species). Supporting spawning aggregations conservation efforts and listing under SPAW Annexes additional species which require regional attention and management.
- Species Recovery Action Plans and Conservation Plans – National and regional recovery plans for species such as sea turtles, regional conservation plan for marine mammals, and support management initiatives for economically important species such as lobster and conch. In coordination and collaboration with relevant intergovernmental organizations such as FAO-WECAFC, CRFM, IAC , CITES and NGOs such as WIDECAST and IUCN.

4.4 SMALL-SCALE FISHERIES

Tackling the bycatch of sea turtles in the multitude of small-scale fisheries typical of coastal communities is intrinsically more difficult due to the great diversity of gear used in these fisheries and to the dispersed nature of the fishing communities (Soykan et al. 2008). One of the most common and problematic SSF gears are gillnets (Moore et al. 2010). In such fisheries, socioeconomic drivers are significant and mitigation approaches must consider these issues carefully. Low cost mitigation technology has been successfully trialed in several fisheries (Ortiz et al. 2016; Peckham et al. 2016; Virgili et al. 2018).

4.4.1 SUSTAINABLE LIVELIHOODS

Developing livelihood diversity in small scale fishing communities could provide a solution to poverty-driven bycatch mortality and targeted catch of sea turtles (Allison and Ellis 2001). Additionally, promotion and access to other protein sources is essential to reduce the levels of turtle exploitation in these fisheries (Mancini et al. 2011).

4.4.2 COMMUNITY BASED MANAGEMENT

Regional and local management programmes dealing specifically with small-scale fishers have begun in recent years and have yielded some noticeable results.

4.5 Illegal, Unreported and Unregulated (IUU) Fisheries

4.5.1 Illegal fishing

Illegal fishing is fishing conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or in contravention of its laws and regulations; conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.

4.5.2 Unreported fishing

Unreported fishing is fishing activities which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or are undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization.

4.5.3 Unregulated fishing

Unregulated fishing is fishing in the area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; orin areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law.

IUU fishing undermines national and regional efforts to conserve and manage fish stocks and, as a consequence, inhibits progress towards achieving the goals of long-term sustainability and responsibility. Moreover, IUU fishing greatly disadvantages and discriminates against those fishers that act responsibly, honestly and in accordance with the terms of their fishing authorizations. If IUU fishers target vulnerable stocks that are subject to strict management controls or moratoria, efforts to rebuild those stocks to healthy levels will not be achieved, threatening marine biodiversity, food security for communities who rely on fisheries resources for protein and the livelihoods of those involved in the sector.

5 SCALE AND IMPORTANCE OF MARINE TURTLE BYCATCH RELATING TO TRADE

5.1 FISHERIES REGULATED BY REGIONAL FISHERIES BODIES (RFBS)

All RFBs that include sea turtles within their jurisdictions have put in place substantial measures to prevent sea turtle bycatch and associated mortality. The only potential situation where a bycaught animal could potentially enter into international trade would be from a vessel with insufficient observer coverage that entered a port where landing controls were inadequate to identify and confiscate the turtle products on arrival. For all of the RFBs considered in this report, the possibility of this occurring would be extremely remote, as confirmed by all of the RFBs that were contacted.

5.2 SMALL-SCALE FISHERIES

It is clear that small scale fisheries are responsible for substantial levels of sea turtle bycatch and targeted catch in a number of regions (Moore et al. 2010). However, these turtles are generally destined for subsistence use, sale to the local community and occasionally national trade. It is unlikely that turtle products could enter into international trade from this source. It be noted that trade routes have been set up for shark fins from remote coastal villages in East Africa and the Pacific to buyers in the Far East (pers obs) and so potentially the same routes could be used to smuggle turtle products. However turtle products are more easily identifiable by customs controls and so small scale fisheries are not likely to be a source of international trade.

5.3 ILLEGAL, UNREPORTED AND UNREGULATED (IUU) FISHERIES

IUU fisheries are a clear threat to sea turtles through bycatch and targeted fisheries and there is substantial evidence that products from the turtles that they catch are destined for international markets.The scale of the impact of these fisheries is largely unknown, but likely to be substantial and there is evidence for links between bycatch / targeted catch and international trade. The key countries where turtle products are known to be targeted for international trade are the waters of the Philippines, Viet Nam, Malaysia and Indonesia where whole turtles are traded directly with Chinese buyers (Riskas et al. 2018). The demand for turtle products in China remains strong (Chan et al. 2007). 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.

6 Opportunities for practical and effective collaboration between CITES, FAO and RFBs

6.1 Fisheries regulated by Regional Fisheries Bodies (RFBs)

6.1.1 Increased observer coverage

Generally, an observer coverage rate of 5 % is thought to be sufficient to identify areas and seasons in which bycatch occurs. However, when observers are not on board fishers may behave differently or treat bycatch differently. The use of 24 hour surveillance video is a potential solution to ensure that turtle bycatch is handled correctly and minimize risk of turtle products being landed.

6.1.2 Encourage better compliance with mitigation measures

Several parties are yet to fully comply with bycatch reduction measures recommended by RFBs. Without effective mitigation measures, turtle bycatch in certain fisheries is a serious threat to populations. Increased numbers of bycaught turtles also increases the chance that they will be retained and potentially be traded.

6.1.3 Collaboration across jurisdictions and between organizations

Sea turtles are wide-ranging; utilizing a variety of habitats across jurisdictional borders for various stages of their life histories. Any conservation measures must protect them at all stages of their life history and within all jurisdictions on their migratory routes, which requires collaboration between a variety of stakeholders.

6.2 Small-Scale Fisheries

6.2.1 Increased capacity for local-level management

Bottom-up, community-based approaches have generally produced the best results in small-scale fisheries. Such approaches have been proven to reduce sea tutle bycath and improve wider sustainability of small scale fisheries in various locations around the world including South America, East Africa and the Pacific (de Castro et al. 2021).

6.2.2 Sustainable sources of livelihood and animal protein

Where turtle take is primarily for subsistence and form a significant part of local communities' protein intake, socioeconomic drivers should be evaluated in order to provide suitable alternatives to reduce the need to consume turtle. However, turtles often have significant cultural values and these may be more difficult replace.

6.3 Illegal, Unreported And Unregulated (IUU) Fisheries

6.3.1 Regional Fisheries Bodies (RFBs) should continue to address IUU fishing

Control of IUU fishing is a key issue in the remit of RFBs and this should continue, with consideration that sea turtle bycatch and direct take is likely a major issue. Essential measures to tackle IUU fishing include identification and tracking of vessel activities at the point of harvest, the landing and transport of fishery products, creation of traceability through the trade chain and deterrent sanctions and IUU vessel lists.

6.3.2 Improved vessel monitoring systems and transhipment regulations

Vessel tracking, either through Vessel Monitoring Systems (VMS) or direct observation is a key tool in the control of IUU fisheries and prevention of transhipment, leading to seizures of turtle catches to remove them from international trade. Building the capacity of relevant nations in modern VMS and encouraging multilateral collaboration are key in dealing with the threat of transhipment.

7 REFERENCES

Allison EH, Ellis F (2001) The livelihoods approach and management of small-scale fisheries. Marine policy 25:377–388

Amandé JM, Ariz J, Chassot E, Chavance P, Delgado de Molina A, Gaertner D, Murua H, Pianet R, Ruiz J (2008) By-catch and discards of the European purse seine tuna fishery in the Indian Ocean. Estimation and characteristics for the 2003-2007 period. Indian Ocean Tuna Commission

Anganuzzi A (2004) Gathering data on unreported activities in Indian Ocean tuna fisheries. Fish Piracy: combating illegal, unreported and unregulated fishing Paris: OECD Publishing 147–154

Angel A, Nel R, Wanless RM, Mellet B, Harris L, Wilson I (2014) Ecological risk assessment of sea turtles to tuna fishing in the ICCAT region. Collect Vol Sci Pap ICCAT 70:2226–2259

Beri R (2011) Piracy in Somalia: Addressing the Root Causes. null 35:452–464

Bolten AB, Bjorndal KA (2003) Experiment to Evaluate Gear Modifiction on Rates of Sea Turtle Bycatch in the Swordfish Longline Fishery in the Azores: Phase 2. University of Florida, Archie Carr Center for Sea Turtle Research,

Boopendranath MR, Prakash RR, Pravin P (2010) A review of the development of the TED for Indian fisheries. South-East Asian (IOSEA) Marine Turtle MoU Website 6:

Bourjea J, Nel R, Jiddawi NS, Koonjul MS, Bianchi G (2008) Sea Turtle Bycatch in the West Indian Ocean: Review, Recommendations and Research Priorities. 14

Broadhurst MK (2000) Modifications to reduce bycatch in prawn trawls: a review and framework for development. Reviews in Fish Biology and Fisheries 10:27–60

Campbell LM, Cornwell ML (2008) Human dimensions of bycatch reduction technology: current assumptions and directions for future research. Endangered Species Research 5:325–334

de Castro RM, Broadhurst MK, Domit C (2021) Towards mitigating marine-mammal and sea-turtle mortalities in small-scale fisheries. Regional Studies in Marine Science 48:101999

Chan SK-F, Cheng I-J, Zhou T, Wang H-J, Gu H-X, Song X-J (2007) A Comprehensive Overview of the Population and Conservation Status of Sea Turtles in China. Chelonian Conserv Biol 6:185

Cheng I-J, Chen T-H (1997) The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. Biological Conservation 82:235–239

CITES Secretariat (2019) Status, scope and trends of the legal and illegal international trade in marine turtles, its conservation impacts, management options and mitigation priorities. 18:

CMS, IOSEA (2016) A Report on Illegal Take of and Trade In Marine Turtles.

Coelho R, Fernandez-Carvalho J, Santos MN (2013) A REVIEW OF FISHERIES WITHIN THE ICCAT CONVENTION AREA THAT INTERACT WITH SEA TURTLES. 40

Costanza AB, Guidino C, Mangel JC, Alfaro-Shigueto J, Verutes G, Caillat M, Samanta A, Hines E (2021) Participatory Risk Assessment of Humpback Whale (Megaptera novaeangliae) and Leatherback Turtle (Dermochelys coriacea) Bycatch in Northern Peru. Frontiers in Marine Science

Crowder LB, Crouse DT, Heppell SS, Martin TH (1994) Predicting the impact of turtle excluder devices on loggerhead sea turtle populations. Ecological applications 4:437–445

Dutton PH, Squires D (2008) Reconciling biodiversity with fishing: a holistic strategy for Pacific sea turtle recovery. Ocean Development & International Law 39:200–222

Early-Capistrán M-M, Sáenz-Arroyo A, Cardoso-Mohedano J-G, Garibay-Melo G, Peckham SH, Koch V (2018) Reconstructing 290 years of a data-poor fishery through ethnographic and archival research: The East Pacific green turtle (Chelonia mydas) in Baja California, Mexico. Fish and Fisheries 19:57–77

Epperly S, Avens L, Garrison L, Henwood T, Hoggard W, Mitchell J, Nance J, Poffenberger J, Sasso C, Scott-Denton E (2002) Analysis of sea turtle bycatch in the commercial shrimp fisheries of southeast US waters and the Gulf of Mexico.

Espinoza EO, Moore MK, Hamlin BC, Baker BW, Espinoza AJ (2021) Forensic characterization of sea turtle oil by ambient ionization mass spectrometry: Caretta caretta, Chelonia mydas, Dermochelys coriacea, Eretmochelys imbricata, Lepidochelys kempii, and Lepidochelys olivacea. Forensic Science International: Animals and Environments 1:100008

FAO and ACCOBAMS (2018) Good practice guide for the handling of sea turtles caught incidentally in Mediterranean fisheries. FAO, Rome, Italy

Finkbeiner EM, Wallace BP, Moore JE, Lewison RL, Crowder LB, Read AJ (2011) Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144:2719–2727

Frazier J (1980) Exploitation of marine turtles in the Indian Ocean. Human Ecology 8:329–370

Gilman E, Brothers N, Kobayashi DR (2007) Comparison of three seabird bycatch avoidance methods in Hawaii-based pelagic longline fisheries. Fisheries Science 73:208–210

Gilman E, Gearhart J, Price B, Eckert S, Milliken H, Wang J, Swimmer Y, Shiode D, Abe O, Hoyt Peckham S, others (2010) Mitigating sea turtle by-catch in coastal passive net fisheries. Fish and Fisheries 11:57–88

Gilman E, Zollett E, Beverly S, Nakano H, Davis K, Shiode D, Dalzell P, Kinan I (2006) Reducing sea turtle by-catch in pelagic longline fisheries. Fish and Fisheries 7:2–23

Hays GC (2004) Good news for sea turtles. Trends in Ecology & Evolution 19:349–351

He P, Jones N (2013) Design and test of a low profile gillnet to reduce Atlantic sturgeon and sea turtle bycatch in Mid-Atlantic monkfish fishery.

Henwood TA, Stuntz WE (1987) Analysis of sea turtle captures and mortalities during commercial shrimp trawling. Fishery Bulletin 85:813–817

Howell E, Kobayashi D, Parker D, Balazs G, Polovina aJJ (2008) TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles Caretta caretta in the Hawaii-based pelagic longline fishery. Endang Species Res 5:267–278

Hykle D (2013) IOTC/IOSEA reports give insights into Indian Ocean fisheries-turtle interactions [WWW Document]. Indian Ocean-South-East Asian Mar. Turt Memo Underst Profile Mon URL http://www ioseaturtles org/pom_detail php

Kennelly SJ, Broadhurst MK (2021) A review of bycatch reduction in demersal fish trawls. Reviews in Fish Biology and Fisheries 31:289–318

Koch V, Nichols WJ, Peckham H, De La Toba V (2006) Estimates of sea turtle mortality from poaching and bycatch in Bahia Magdalena, Baja California Sur, Mexico. Biological Conservation 128:327–334

Lam T, Lingxu, Takahashi S, Burgess EA (2012) Market forces: an examination of marine turtle trade in China and Japan. TRAFFIC East Asia,

Lewison RL, Crowder LB (2007) Putting longline bycatch of sea turtles into perspective. Conservation biology 21:79–86

Lewison RL, Crowder LB, Read AJ, Freeman SA (2004) Understanding impacts of fisheries bycatch on marine megafauna. Trends in ecology & evolution 19:598–604

Lewison RL, Crowder LB, Wallace BP, Moore JE, Cox T, Zydelis R, McDonald S, DiMatteo A, Dunn DC, Kot CY (2014) Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. Proceedings of the National Academy of Sciences 111:5271–5276

Lewison RL, Soykan CU, Franklin J (2009) Mapping the bycatch seascape: multispecies and multi-scale spatial patterns of fisheries bycatch. Ecological Applications 19:920–930

Limpus CJ, Miller JD (1990) The Use of Measured Scutes of Hawksbill Turtles, Eretmochelys-Imbricata, in the Management of the Tortoiseshell (Bekko) Trade. Wildlife Research 17:633–639

Lin L, Li S, Chen M, Parham JF, Shi H (2021) Sea turtle demand in China threatens the survival of wild populations. iScience 24:102517

Lopez M, Fallabrino A (2001) New kind of illegal trade of marine turtles in Uruguay. Marine Turtle Newsletter 91:

Mack D (1983) Worldwide trade in wild sea turtle products: an update. Marine Turtle Newsletter 24:5

Magnuson JJ, Bjorndal K, DuPaul W, Graham G, Owens D, Peterson C, Pritchard P, Richardson J, Saul G, West C (1990) Decline of the sea turtles: causes and prevention. Washington, DC

Mancini A, Senko J, Borquez-Reyes R, Póo JG, Seminoff JA, Koch V (2011) To Poach or Not to Poach an Endangered Species: Elucidating the Economic and Social Drivers Behind Illegal Sea Turtle Hunting in Baja California Sur, Mexico. Human Ecology 39:743–756

Martínez-Ortiz J, Aires-da-Silva AM, Lennert-Cody CE, Maunder MN (2015) The Ecuadorian Artisanal Fishery for Large Pelagics: Species Composition and Spatio-Temporal Dynamics. PLOS ONE 10:e0135136

Mazaris AD, Fiksen Ø, Matsinos YG (2005) Using an individual-based model for assessment of sea turtle population viability. Population Ecology 47:179–191

Mazaris AD, Schofield G, Gkazinou C, Almpanidou V, Hays GC (2017) Global sea turtle conservation successes. Science Advances 3:e1600730

Mejías-Balsalobre C, Restrepo J, Borges G, García R, Rojas-Cañizales D, Barrios-Garrido H, Valverde RA (2021) Local community perceptions of sea turtle egg use in Tortuguero, Costa Rica. Ocean & Coastal Management 201:105423

Miller EA, McClenachan L, Uni Y, Phocas G, Hagemann ME, Van Houtan KS (2019) The historical development of complex global trafficking networks for marine wildlife. Science advances 5:eaav5948

Moore JE, Cox TM, Lewison RL, Read AJ, Bjorkland R, McDonald SL, Crowder LB, Aruna E, Ayissi I, Espeut P, Joynson-Hicks C, Pilcher N, Poonian CNS, Solarin B, Kiszka J (2010) An interview-based approach to assess marine mammal and sea turtle captures in artisanal fisheries. Biological Conservation 143:795–805

Moore JE, Wallace BP, Lewison RL, Žydelis R, Cox TM, Crowder LB (2009) A review of marine mammal, sea turtle and seabird bycatch in USA fisheries and the role of policy in shaping management. Marine Policy 33:435–451

Murray KT (2009) Characteristics and magnitude of sea turtle bycatch in US mid-Atlantic gillnet gear. Endangered Species Research 8:211–224

NOAA (2019) Sea Turtle handling/release guidelines: Quick reference for hook and line fisheries English / Vietnamese / Spanish | Bycatch Management Information System (BMIS). https://www.fisheries.noaa.gov/atlantic-highly-migratory-species/safe-handling-release-and-identification-workshops

da Nóbrega Alves RR (2006) Use of marine turtles in zootherapy in Northeast Brazil. Marine Turtle Newsletter 112:16–17

Northridge S, Coram A, Kingston A, Crawford R (2017) Disentangling the causes of protected-species bycatch in gillnet fisheries. Conservation Biology 31:686–695

Ortiz N, Mangel JC, Wang J, Alfaro-Shigueto J, Pingo S, Jimenez A, Suarez T, Swimmer Y, Carvalho F, Godley BJ (2016) Reducing green turtle bycatch in small-scale fisheries using illuminated gillnets: the cost of saving a sea turtle. Marine Ecology Progress Series 545:251–259

Peckham SH, Díaz DM, Walli A, Ruiz G, Crowder LB, Nichols WJ (2007) Small-scale fisheries bycatch jeopardizes endangered Pacific loggerhead turtles. PloS one 2:e1041

Peckham SH, Lucero-Romero J, Maldonado-Díaz D, Rodríguez-Sánchez A, Senko J, Wojakowski M, Gaos A (2016) Buoyless nets reduce sea turtle bycatch in coastal net fisheries. Conservation Letters 9:114–121

Poti M, Long SL, Rusli MU, Mohd Jani J, Hugé J, Dahdouh-Guebas F (2021) Changing trends and perceptions of sea turtle egg consumption in Redang Island, Malaysia. Ecology and Society 26:

Pritchard PCH (1980) The Conservation of Sea Turtles: Practices and Problems1. American Zoologist 20:609–617

Putman N, Hawkins J, Gallaway B (2020) Managing fisheries in a world with more sea turtles. Proceedings of the Royal Society B: Biological Sciences 287:20200220

Quiñones J, Quispe S, Galindo O (2017) Illegal capture and black market trade of sea turtles in Pisco, Peru: the never-ending story. Latin american journal of aquatic research 45:615–621

Ridings P, Cole A, Goldsworthy L, Kaye S (2018) Report of the South Pacific Regional Fisheries Management Organisation Performance Review Panel. Wellington, New,

Riskas KA, Tobin RC, Fuentes MMPB, Hamann M (2018) Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. Biological Conservation 217:232–239

Robins JB (1995) Estimated catch and mortality of sea turtles from the east coast otter trawl fishery of Queensland, Australia. Biological Conservation 74:157–167

Romanov EV (2002) Bycatch in the tuna purse-seine fisheries of the western Indian Ocean.

Schoppe S, Antonio R (2009) Marine turtle trade in the Philippines.

Shiode D, Tokai T (2004) A review of development, modification and implementation of TED(Turtle Excluder Device) to reduce sea turtle bycatch in trawl fisheries. FAO fisheries report 171–177

Sims M, Cox T, Lewison R (2008) Modeling spatial patterns in fisheries bycatch: improving bycatch maps to aid fisheries management. Ecological applications 18:649–661

Stiles D (2008) An assessment of the marine turtle products trade in Viet Nam. TRAFFIC Southeast Asia Petaling Jaya,

Suryan RM, Saba VS, Wallace BP, Hatch SA, Frederiksen M, Wanless S (2009) Environmental forcing on life history strategies: Evidence for multi-trophic level responses at ocean basin scales. Progress in Oceanography 81:214–222

Swimmer Y, Gutierrez A, Bigelow K, Barceló C, Schroeder B, Keene K, Shattenkirk K, Foster DG (2017) Sea turtle bycatch mitigation in US longline fisheries. Frontiers in Marine Science 4:260

Valverde RA, Holzwart KR (2017) Sea turtles of the Gulf of Mexico. Habitats and biota of the Gulf of Mexico: before the Deepwater Horizon oil spill. Springer, pp 1189–1351

Virgili M, Vasapollo C, Lucchetti A (2018) Can ultraviolet illumination reduce sea turtle bycatch in Mediterranean set net fisheries? Fisheries Research 199:1–7

Wallace BP, Heppell SS, Lewison RL, Kelez S, Crowder LB (2008) Impacts of fisheries bycatch on loggerhead turtles worldwide inferred from reproductive value analyses. Journal of Applied Ecology 45:1076–1085

Wallace BP, Kot CY, DiMatteo AD, Lee T, Crowder LB, Lewison RL (2013) Impacts of fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. Ecosphere 4:1–49

Wallace BP, Lewison RL, McDonald SL, McDonald RK, Kot CY, Kelez S, Bjorkland RK, Finkbeiner EM, Helmbrecht S, Crowder LB (2010) Global patterns of marine turtle bycatch. Conservation letters 3:131–142

Wang JH, Fisler S, Swimmer Y (2010) Developing visual deterrents to reduce sea turtle bycatch in gill net fisheries. Marine Ecology Progress Series 408:241–250

WCPFC (2009) 5th Regular Session of the Scientific Committee.

Wold C (2002) The status of sea turtles under International environmental law and International environmental agreements. null 5:11–48

Žydelis R, Lewison RL, Shaffer SA, Moore JE, Boustany AM, Roberts JJ, Sims M, Dunn DC, Best BD, Tremblay Y (2011) Dynamic habitat models: using telemetry data to project fisheries bycatch. Proceedings of the Royal Society B: Biological Sciences 278:3191–3200

Žydelis R, Wallace BP, Gilman EL, Werner TB (2009) Conservation of marine megafauna through minimization of fisheries bycatch. Conservation Biology 23:608–616